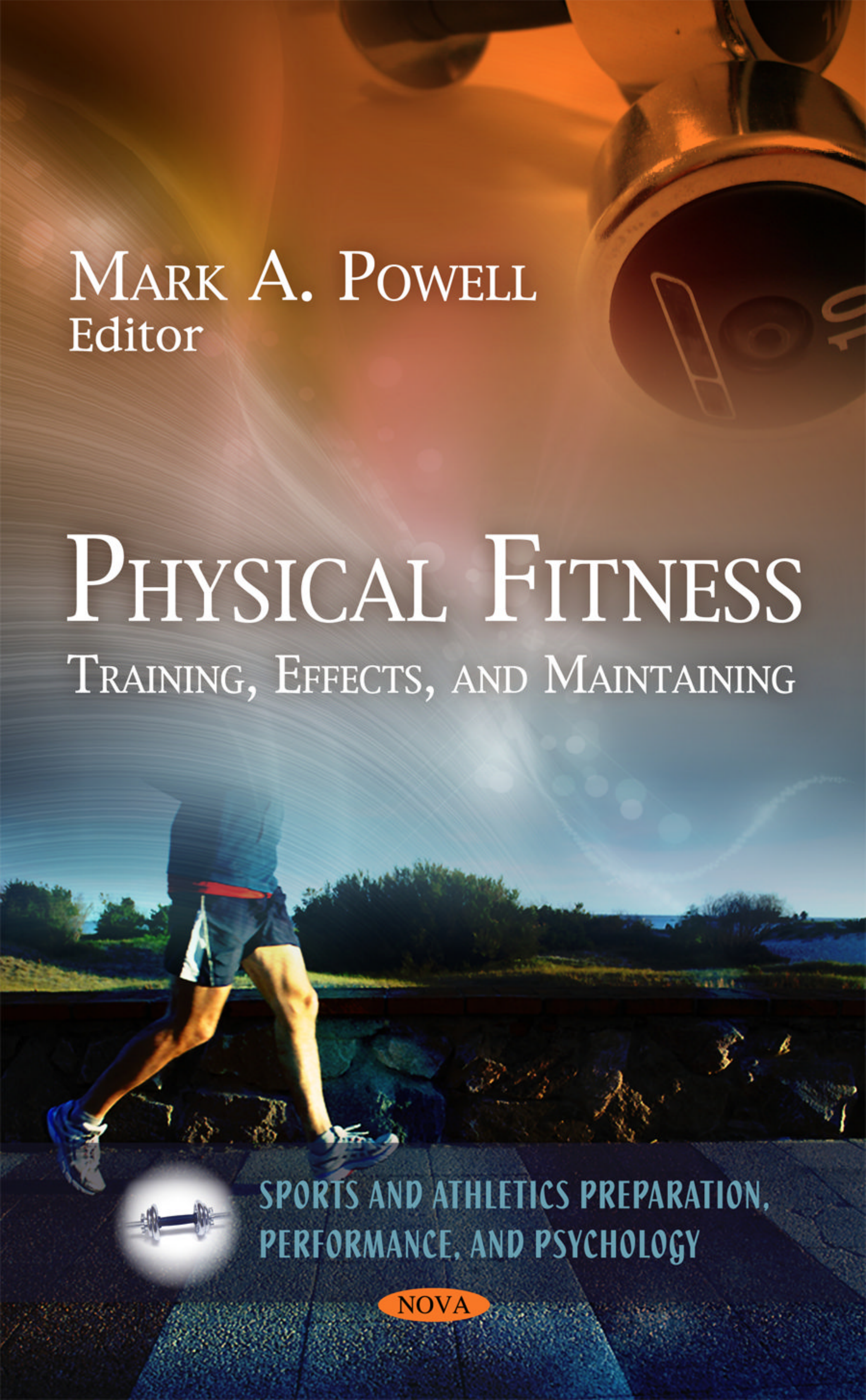
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Editor
PHYSICAL FITNESS
TRAINING, EFFECTS, AND MAINTAINING
SPORTS AND ATHLETICS PREPARATION,
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MARK A. POWELL
EDITOR

Nova Science Publishers, Inc.
New York

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LIBRARY OF CONGRESS CATALOGING-IN-PUBLICATION DATA
Physical fitness : training, effects, and maintaining / editor, Mark A. Powell.
p. cm.
Includes index.
ISBN 978-1-62100-043-3 (eBook)
1. Physical fitness. I. Powell, Mark A.
RA781.P567 2009 *613.7'1--dc22*
2010023915

Published by Nova Science Publishers, Inc. † New York

CONTENTS

PREFACE

Physical fitness comprises two related concepts: general fitness (a state of health and well-being) and specific fitness (a task-oriented definition based on the ability to perform specific aspects of sports or occupations). Physical fitness is generally achieved through exercise and is considered a measure of the body's ability to function efficiently and effectively in work and leisure activities, to be healthy, to resist hypokinetic diseases, and to meet emergency situations. This new and important book gathers the latest research from around the globe in the study of physical fitness with a focus on such topics as promoting physical fitness and sports for individuals with developmental disabilities; the effects of chronic low back pain on physical fitness; using mental tricks to enhance physical fitness and the unique issues of physical activity during pregnancy.

Chapter 1 - The common training practice of active recovery, using low intensity of exercise, is often applied during the interval between repeated exercise bouts and following training sessions with the intention to promote the restoration of muscle metabolism and hasten the recovery of performance. The purpose of this chapter is to address the metabolic limitations concerning the use of active recovery during and after training sessions of high or maximum intensity. Although there is a consensus concerning the faster lactate removal after active recovery, there is no clear evidence concerning the effect of this practice on performance. This is probably attributed to different exercise modes and experimental protocols that have been used to examine the effectiveness of active compared to passive recovery. Active compared to passive recovery increases performance in long duration sprints (15 to 30 s and 40 to 120 s) interspaced with long duration intervals (i.e. exercise to rest ratio 1:8 to 1:15), but this is less likely after short duration repeated sprints (4 to 15

s) interspaced with a relatively short rest intervals (i.e. exercise to rest ratio of 1:5). The duration or the intensity, and possibly the mode of exercise, may be critical factors affecting performance after active recovery as compared to passive recovery. This in turn affects the energy systems contributing to the exercise bout that follows. It is likely that active compared to passive recovery, following long duration sprints, creates a beneficial intramuscular environment due to a faster restoration of acid-base balance within the muscle cell. However, the oxygen dependent PCr resynthesis may be impaired by active recovery when it is applied between short duration sprints and especially when the recovery interval is short. Furthermore, the intensity of active recovery can also be crucial for an effective performance outcome. Low intensity should be used for short duration sprints whereas the intensity at the "lactate threshold" may be more appropriate between long duration sprints. In addition, active compared to passive recovery applied immediately after high intensity training may help to maintain performance during the next training session. Coaches should be aware of the above limitations when using active recovery to improve the effectiveness of training.

Chapter 2 - The aims of four investigations presented in this chapter were to assess: a) the contribution of selected factors to athletics and basketball performance; b) basketball abilities before and after a training period during one and two following sports seasons; c) the variation of sports abilities by subjects' mental retardation (MR) level. In the first and second investigations all participants performed fitness tests assessing body composition (BC), flexibility (SR), muscular strength and endurance (HG, SUP and PUP), explosive leg power (SLJ), cardiovascular endurance (ST), balance ability (FT), and motor coordination (TUGT). In the first investigation, the selected athletics performances were as follow: 60 m, 300 m, 400 m in walking, Standing long jump, Vortex throw or 100 m, Shot put, and Long jump. TUGT and body weight had contributions to 60 m, the %body fat to 300 m and to 100 m. The SLJ had contribution to Vortex throw and to Standing long jump. The PUP had contribution to Shot put. Body weight had contribution to Long jump. In the second investigation, showed that greater SLJ and PUP had positive contributions to ball handling; SLJ had positive contribution to reception and shooting. The HG and PUP had positive contributions to passing. In the third and fourth investigations, all athletes were tested through a basketball test battery (Guidetti, 2009) before and after a training period preceding the championship, during one and two following sports seasons, respectively. The purpose was to propose adapted basketball tests useful to evaluate whether individual and team ability level is adequate to participate in a specific Championship category. This test battery simplified the classification of basketball competitors with mental retardation by using functional quantitative measures. Moreover, it is also useful to follow up the training improvement in athletes with mental retardation during two consecutive sports seasons.

All our investigations showed that specific sport training could improve fitness of individuals with MR. Moreover, the possibility to determine the contribution of selected factors to sport performance should be addressed in training to help athletes to perform successfully in their competitions.

Chapter 3 - *Background:* Individuals with intellectual and developmental disability (IDD) too frequently maintain a sedentary life style, resulting in health harming consequences and early aging. Physical intervention programs have been suggested and implemented with this population in the past, mostly with success, but with extreme costs. *The Interventions*: The present chapter describes three low cost intervention programs for children and adults at different functional levels and intellectual ability. All programs have been implemented by volunteers trained and supervised by an experienced physical therapist.

Project 1 – 15 children (Mean age: 7.9) diagnosed at a moderate-severe cognitive level, were trained daily on a treadmill for the duration of two month with significant improvements in aerobic capacity and functional ability.

Project 2 – 17 ambulating adults (mean age: 42) diagnosed with moderate cognitive level, were trained twice weekly on a treadmill, for the duration of one year. Results were compared with a control group ($n=17$) matched for function, gender, age, and primary diagnosis and showed significant reduction in pulse at rest ($p<0.05$) and during exercise ($p<0.001$) only for the trained participants. A significant reduction was also observed in infirmary visitation ($P<0.025$) for the research group alone.

Project 3 – 4 adults (mean age: 47.5) constant wheel chair users who have never walked, diagnosed with moderate cognitive level, were trained twice weekly on a four wheeled walker, for the duration of two month. Results were compared with a control participant ($n=1$) and showed significant reduction in pulse at rest ($p<0.05$) and during exercise ($p<0.001$) in muscle strength ($p<0.001$) and functional ability ($p<0.01$).

Conclusions:The results of all three projects indicate that a low cost exercise program can yield extremely positive results in many areas that influence clients' health. The author suggests implementing such programs for individuals with IDD on a regular basis since childhood and across their lifespan. Further research is needed to examine the long term effect of such intervention programs on longevity, morbidity and mortality.

Chapter 4 - Low back pain is a condition that greatly affects the physical performance of patients and represents today a major health problem, not only due to its physical and psychological implications but also because of the high costs in terms of treatment and sick-leave days. The level of aerobic fitness determines one's quality of life, to the extent that adequate fitness allows one to perform activities of daily living. A long-term pain-induced inhibition of activity like that induced by chronic low back pain may cause further physical deconditioning. This deconditioning can perpetuate the sensation of pain and create a vicious cycle from which the patient cannot escape.

For too long, rest has been the most frequently prescribed treatment in patients with low back pain. However, several scientific publications now acknowledge the importance of physical reconditioning in the rehabilitation of these patients, based on the hypothesis that they are deconditioned. The current trend is to treat low back pain using intensive physical training programs, although the measured values of physical fitness level in chronic low back pain patients are contradictory.

In this paper, scientific publications focusing on the measurement of aerobic capacity in patients with chronic low back pain are reviewed. Mechanisms by which physical deconditioning may contribute to the onset or chronicity of low back pain are discussed. Previous errors in the techniques and interference of limiting factors in the measurement of maximum aerobic capacity may explain the confusing results on physical fitness measurement. Lastly, some suggestions for individual exercise prescription and for future research in the field of reconditioning of these patients are made.

Chapter 5 - The goal of enhanced performance in sports and fitness training is an ancient pursuit. But using the mind to train itself, and adopting approaches to enable the mind to train the body, is a bold new enterprise.

The brain can be altered in direct response to pharmaceutical applications, surgical techniques, and sudden trauma. It can also be impacted through experience.

According to the most recent studies in neuroplasticity, the brain can be altered through sheer mental experience, in realms that are perceptual, emotional, conceptual, and social. If the experience is related to calisthenics training, the brain's altered structure can lead to a cascade effect in the larger physical organism, influencing muscular strength, coordination, and fitness function.

The basic result: if you can engineer the brain's experience, you can engineer the brain.

The "experience" can be a real life experience, but it can also be simulated – an artificial condition, facilitated through a virtual reality experiment, perceptual deception, or sensory hoax.

A brief list of studies suggests the potential of mind-over-matter, the "matter," in this case, equating to the physical body. My own speculative article (DiPrete, 2008) touches upon the work of Ramachandran and others, and calls for more innovations in this particular line of research.

Chapter 6 - Maintaining good level of physical fitness (PF) is important to the health of children and adolescents. Unfortunately, many countries shown that children and adolescent's PF level was declining in the past decade and this declination was found to be associated with low level of physical activity (PA). Although insufficient PA was attributed by multiple factors, prolong exposure to screen-based activities (i.e., TV viewing and video game plays) was claimed as one of the major factors. Growing body of evidence has been suggesting that Active Video Game (AVG) play may be a promising tool to reverse this physically inactive lifestyle in children and adolescents. However, before applying AVG on PA and PF interventions, a better understanding on this emerging tool is essential. The purposes of this chapter are to provide an overview regarding the rationale and efficacy of applying AVG to promote PA and PF in children and adolescents. In additional, potential challenges for AVG research are also discussed.

Chapter 7 - Physical activity is vital for overall health maintenance, particularly cardiovascular health. Additionally, physical activity is important for decreasing the risk of cancer and osteoporosis in women. Physical fitness, a benefit of physical activity, is important during pregnancy and postpartum periods for both women and their babies. As women became more aware of this issue, their participation in physical activity increased. Upon becoming pregnant, many women posed their Ob/Gyn physicians with the question, "is physical activity during pregnancy safe?" Initially, little was known about the effects physical activity had on the expectant mother or fetal development. Research has led to a better understanding of maternal and fetal physiology and findings highlight the importance of physical activity during this time. This chapter provides an overview, which examines aspects of physical activity in regard to pregnant and lactating women. Based on the available literature, physicians have shifted their focus from assuring patients that physical activity during gestation is safe to encouraging physical activity during pregnancy because of the potential benefits to both the fetus and mother. Ultimately, these benefits are realized at labor and delivery and during the mother's recovery period. Current research into the fetal and neonatal benefits of maternal physical activity is explored. Lactation represents a continuation of the pregnancy, as the mother continues to supply nourishment for her infant. The effects of physical activity during lactation are viewed from the maternal and infant perspective. As research advances, American College of Obstetricians and Gynecologists (ACOG) guidelines continue to reflect these gains in information. Lastly, the chapter expresses what has been done, and what is currently being done to encourage women to stay physically active throughout their reproductive lifespan.

Chapter 8 - Results from studies involving adult participants have definitively established that physical activity and cardiorespiratory fitness are inversely correlated to morbidity and mortality. The evidence of the health benefits for physically active and fit adults is well known. There is a wealth of data which has shown that physically active and fit adults can help attenuate the effects of hypertension, insulin resistance, hyperlipidemia, obesity and cancer. However, the relationship between activity, fitness and the health benefits during childhood are less well established. Although it is intuitive to propose that an active child will become an active adult, the research evidence is weak. Similarly, the extent to which children's fitness and activity must decrease to seriously compromise their current or future health is also unknown. There is however growing concern for the future health status of children due to the increased levels of overweight and obese children and increased reporting of cardiovascular risk factors. Prospective data is needed to elucidate the complexity of these relationships. This complexity is partially due to problems related to 1) methodology i.e. how do we measure activity and health outcomes precisely; 2) biology i.e. children are growing and maturing at different rates and 3) sociology i.e. the effects of the environment. These problems therefore pose real challenges for policy makers as to whether they should concentrate resources on those child individuals who are deemed 'at risk' i.e. low fitness and low physical activity patterns or to focus across the whole child population. This review will explore the relationships between physical fitness, activity and health in young people as well as describing the evidence for health benefits in this age group. The review will also discuss the implications for strategies of health related physical activity promotion at local and national levels.

In: Physical Fitness: Training, Effects and… ISBN: 978-1-61728-672-8
Editor: Mark A. Powell

Chapter 1

ACTIVE VERSUS PASSIVE RECOVERY: METABOLIC LIMITATIONS AND PERFORMANCE OUTCOME

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ABSTRACT

The common training practice of active recovery, using low intensity of exercise, is often applied during the interval between repeated exercise bouts and following training sessions with the intention to promote the restoration of muscle metabolism and hasten the recovery of performance. The purpose of this chapter is to address the metabolic limitations concerning the use of active recovery during and after training sessions of high or maximum intensity. Although there is a consensus concerning the faster lactate removal after active recovery, there is no clear evidence concerning the effect of this practice on performance. This is probably attributed to different exercise modes and experimental protocols that have been used to examine the effectiveness of active compared to passive recovery. Active compared to passive recovery increases performance in long duration sprints (15 to 30 s and 40 to 120 s) interspaced with long duration intervals (i.e., exercise to rest ratio 1:8 to 1:15), but this is less likely after short duration repeated sprints (4 to 15 s) interspaced with relatively short rest intervals (i.e., exercise to rest ratio of 1:5). The duration or the intensity, and possibly the mode of exercise, may be critical factors affecting performance after active recovery as compared to passive recovery. This in turn affects the energy systems contributing to the exercise bout that follows. It is likely that active compared to passive recovery, following long duration sprints, creates a beneficial intramuscular environment due to a faster restoration of acid-base balance within the muscle cell. However, the oxygen dependent PCr resynthesis may be impaired by active recovery when it is applied between short duration sprints and especially when the recovery interval is short. Furthermore, the intensity of active recovery can also be crucial for an effective performance outcome. Low intensity should be used for short duration sprints whereas the intensity at the "lactate threshold" may be more appropriate between long duration sprints. In addition, active compared to passive recovery applied immediately after high intensity training may help to maintain performance during the next training session. Coaches should be aware of the above limitations when using active recovery to improve the effectiveness of training.

INTRODUCTION

Training sessions using repeated bouts of high intensity exercise as an integral part of rutine practice are essential for athletes participating in high power and/or speed sports. The event period of these sports may last 4 to 30 s (short) or 40 to 120 s (long) and as a rule, athletes perform their training with the mode of exercise in which they compete (i.e., running, cycling, swimming, other locomotory activities). In addition, athletes often participate in repeated events within a competition. During training of high intensity, athletes experience fatigue and their performance declines. This drop in performance is observed both within a single sprint as well as during successive sprints of maximum intensity (Bogdanis et al., 1995; Spencer et al., 2006; Toubekis et al., 2005).

The fatigue caused during sprinting is a multi-factorial phenomenon that is mainly attributed to acute metabolic alterations. The rapid activation of glycolysis and the concomitant increase of the hydrogen ion concentration (H^+) induce intramuscular acidosis and lead to the decline of performance (Gaitanos et al., 1993; Bogdanis et al., 1998; Hargreaves et al., 1998).

Moreover, the depletion of phosphocreatine (PCr) stores occurring simultaneously with the increased levels of inorganic phosphate (Pi) are only two of the many inter-dependent factors that may impair muscle function (Bogdanis et al., 1995; Westerbland and Allen 2003). In the past, lactate was believed to be a factor contributing to fatigue, and research was focused on methods to eliminate this "fatigue agent" from muscles and subsequently from blood. Early research findings showed that in comparison to passive rest, active recovery (light exercise) facilitates the removal of lactate from muscles and blood (Gisolfi et al., 1966).

Although blood and muscle lactate may not have a direct impact on muscle function and performance (Gladden 2004), it is believed that active recovery applied within a training set, between sets, or after a training session is always beneficial in an athlete's performance. This opinion disregards recent findings that suggest a number of limitations in the application of active recovery during sprinting (Toubekis et al., 2005, 2006, 2008; Spencer et al., 2006, 2008; Dupont et al., 2007; Buchheit et al., 2009). Several factors may have an impact on the efficacy of active recovery compared to passive recovery on performance maintenance following maximum intensity repeated bouts of sprint exercise. These include the duration of the sprint, the interval duration between sprints, the duration of active recovery within the interval time period, the number of repetitions, as well as the mode of exercise applied during active recovery. In addition, the training status of the participants may also be a confounding factor.

This chapter presents the changes in performance after active compared to passive recovery during repeated bouts of maximum intensity exercise. It also explains the underlying metabolic limitations that may influence the performance outcome during various modes of exercise.

ACTIVE RECOVERY AND BLOOD LACTATE

There is a consensus in scientific literature that active recovery enhances the rate of blood lactate removal. However, the rate of blood lactate removal is dependent on the intensity of active recovery (Belcastro and Bonen, 1975), arterial lactate concentration (Stanley et al., 1985), muscle glycogen content (Essen et al. 1975) and muscle fibre type (Bonen et al. 1978). In addition, increased blood flow may facilitate oxidation of lactate within the muscle (Brooks, 1986), while active recovery may increase the efflux and flow of lactate to other tissues for oxidation (Lindinger et al., 1990) resynthesis to glycogen (Hermansen and Vaage, 1977) or both (Gollnick et al., 1986). Furthermore, the muscle mass involved during active recovery may also be important for blood lactate removal. When the active muscle mass is increased (e.g. leg exercise during recover), blood lactate clearance is better than when smaller muscles are involved (McGrail et al., 1978).

Moreover, the training status of the individuals (Taoutaou et al., 1996) and the mode of the previous exercise, as well as the mode of recovery exercise may be contributing factors to blood lactate removal. It is also suggested that active recovery must be applied with the same kind of activity as the previous exercise, since sport specific active recovery enhances the removal of blood lactate faster than non specific active recovery (Krukau et al., 1987, Siebers and McMurray, 1981). It is suggested that, if active recovery is performed with muscles that were previously inactive (legs), arterial hypotension and a slower release of lactate from the previously active arm muscles may occur (Hildebrandt et al., 1992). However, following leg exercise, the rate of lactate removal was similar irrespective of using the active or inactive leg for active recovery, whereas, a decreased rate of lactate removal was observed when the arms were used for active recovery (McLoughlin et al., 1991). It should be noted that the difference in the rate of lactate removal between the arm and leg active recovery may be affected by the relative intensity of the selected muscle group since the selected intensity of active recovery may increase lactate production during arm exercise (McLoughlin et al., 1991). The literature for lactate metabolism is extensive and has been reviewed by expert scientists. Nevertheless, in this chapter only some factors contributing to lactate elimination will be discussed, in particular those related to performance on a subsequent sprint.

The Intensity and Mode of Active Recovery

The intensity of active recovery may be important for performance because it is related to the energy spent within the interval period between sprints. Different "ideal" recovery exercise intensities have been reported for cycling (Belcastro and Bonen, 1975, Bonen et al., 1978), running (Hermansen and Stensvold, 1972, Gisolfi et al., 1966) or swimming (Cazorla et al., 1983, McMaster et al., 1989). When comparing the different modes of exercise, it is likely that lactate removal during active recovery may be faster after swimming compared to running following exercise that had increased the blood lactate to similar concentrations (Denadai et al., 2000). Lactate removal rate after active recovery was higher during swimming (5.3%·min^{-1};Cazorla et al., 1983) compared to cycling (2.9%·min^{-1} at 29% of VO_2max; McGrail et al., 1978, 3.2%·min^{-1} at 32% of VO_2max; Belcastro and Bonen, 1975) or running (4.5%·min^{-1} at 63% of VO_2max; Hermansen and Stensvold, 1972). It is suggested that the ideal intensity should not exceed the individual "anaerobic threshold" (Stamford et al., 1981). It has been reported that the most effective intensity of active recovery for lactate removal is related to the individual "anaerobic threshold", suggesting that an intensity of 10% of VO_2 max below the "anaerobic threshold" is the most efficient (McLellan and Skinner 1982). However, there is evidence that athletes are able to self-select the intensity of active recovery, and no difference was observed in the lactate removal between the self-selected and the "ideal" active recovery intensity (Bonen and Belcastro, 1976; Cazorla et al., 1983).

Even though the reported intensities of active recovery are very useful in making comparisons in the scientific literature, they offer no help to the coaches, since they usually have no data that allow them to express swimming, running or cycling speed during a training session as a percentage of VO_2max. Expression of active recovery as percentage of the speed attained in a race distance may be more helpful to coaches. For example, swimming speed corresponding to 60-70 % of the 100 m speed (55 to 73 % of VO_2max) was effective in faster lactate removal than passive rest (Cazorla et al., 1983). It was reported that 65% of maximum velocity of 200 yd swimming was the most efficient recovery intensity; however, the velocity of 55 or 75% was equally effective for lactate removal (McMaster et al., 1989). The self-selected pace of active recovery in the study of Reaburn and Mackinnon (1990) corresponded to 63 % of the 100 m swimming speed and significantly improved the half time of lactate removal compared to passive recovery. The faster lactate removal during running has been reported to correspond to velocity at the ventilatory threshold or below the ventilatory threshold in triathletes (Baltari et al., 2005) and soccer players (Baltari et al., 2004). Unfortunately, besides swimming there are no data to report the running or cycling intensities as a percentage of performance time or speed. In summary, the intensity of active recovery should be below the intensity that increases the lactate production within the muscle. A question which arises however is whether the intensity below the “lactate or ventilatory threshold” that maximizes blood lactate removal during active recovery is also the most appropriate for performance recovery during a subsequent exercise bout. This issue will be discussed in a following paragraph within this chapter.

The Duration of Active Recovery

The duration of active recovery should balance between an effective lactate removal and time availability within and after a training session. In most of the studies, the duration of active recovery was long (20 to 60 min; McGrail et al., 1978; Cazorla et al., 1983; Baltari et al., 2004). The most significant decrease in blood lactate concentration was observed after the fifth minute of recovery (McGrail et al., 1978). However, using swimming for recovery (500 yd, ~8 min) the blood lactate concentration did not change compared to passive rest, and at least fifteen minutes (1000 yd swimming) was needed to reach near resting concentration (Beckett and Steigbigel 1993). This was probably attributed to low post-exercise lactate values. Cazorla et al., (1983) reported that 20 minutes of active recovery eliminated blood lactate at a level equal to 60 min of passive recovery. Furthermore, five minutes as well as ten minutes of active recovery showed a similar rate of lactate removal, while both rates were faster than passive recovery (Toubekis et al., 2008a). It is likely that 10 to 15 minutes of active recovery is adequate to reduce blood lactate compared to passive recovery. However, it should be noted that blood lactate may be different from muscle lactate.

Muscle Blood Flow and Lactate Removal

Adequate muscle blood flow is important for energy supply and maintenance of homeostasis in the muscle and plays a critical role in the prevention of muscular fatigue (Sjogaard, 1987). During dynamic exercise, muscle blood flow (MBF) increases linearly with increasing exercise intensity and is dependent on mean arterial blood pressure (MABP), venous blood pressure (VBP) and local vascular resistance (LVR) (Sjogaard, 1987). This is described by the Haagen -Poiseuille equation:

$$\text{MBF} = (\text{MABP} - \text{VBP}) \times \text{LVR}^{-1}$$

From this equation, we can conclude that MBF decreases when LVR or VBP increases, and increases when MAPB increases and LVR decreases. During dynamic muscle contractions, vascular resistance decreases and this increases the MBF (Laughlin and Armstrong, 1985, Delp and Laughlin 1998). This has been confirmed during knee extension exercise by using invasive techniques (Bangsbo et al., 1993, 1994). Additionally, the effect of muscular contractions (muscle pump) facilitates increased MBF by changing the arterial-venous blood pressure gradient (Rowel, 1993).

The measurement of muscle blood flow in humans in vivo is very difficult, given that each muscle may have a different blood flow at any given time (Rowel, 1993). Suzuki and Bonde-Peterson (1983) found increased MBF (measured by 133-Xe clearance) after 100 and 400 m running. The MBF was maintained for a longer period after the 400 m run compared to the 100 m run. In other types of exercise such as swimming, a horizontal body position changes the internal hydrostatic pressure. It has been shown that in the supine position, the hydrostatic pressure is similar in all parts of the body (Wilcock et al., 2006). In addition, the total peripheral resistance decreases during supine compared to seated recovery (Johnson et al., 1990). These differences between exercise modes such as land-based (running, cycling) and water-based activities (swimming) may cause a higher stroke volume and blood pressure during swimming compared to running exercise (Holmer et al., 1974) and possibly affect the muscle blood flow. At this point, it should be considered that during the interval period after a swimming bout, in most of cases, swimmers stand in an upright position in the water. Using this practice, swimmers may eliminate any positive effect of horizontal position on haemodynamics. However, even in the upright position in the water up to the mid-sternum level, swimmers may benefit from the hydrostatic pressure applied on their body (Wilcock et al., 2006). Swimmers, who go out of the pool during the rest interval may experience a decrease in performance during a maximum intensity training set (Buchheit et al., 2010). In summury, active recovery of about 10 to 15 minutes will maintain an increased muscle blood flow and will decrease blood and muscle lactate levels.

THE RATIONALE FOR USING ACTIVE RECOVERY

Following a sprint of short duration PCr stores are decreased, muscle lactate is high and a disturbance in acid base balance (pH decrease) occurs. The expected beneficial effect of active recovery on performance is based on a faster restoration of muscle homeostasis. Therefore, muscle lactate should decrease and muscle pH and PCr should recover as soon as possible. Muscle lactate content may not affect performance during short duration repeated sprints (Bogdanis et al., 1995). However, the increased activation of glycolysis during repeated sprints will increase the H^+ concentration and will decrease the muscle pH. A faster restoration of muscle pH may facilitate the function of glycolysis providing the ATP demanded for sprinting (Sayrio et al., 2003). This is because the low pH may affect the function of key glycolytic enzymes (i.e. phosphorylase, phosphofructokinase). Despite muscle lactate, the PCr stores are much more important for performance maintenance during short duration sprints (Bogdanis et al., 1995; Spencer et al., 2008). Therefore, by applying active recovery, it is assumed that the exercise-induced increase in muscle blood flow will enhance muscle oxygenation and this, in turn, will facilitate PCr resynthesis.

Findings from research used magnetic resonance spectroscopy show that increased oxygen availability will facilitate PCr resynthesis (Haseler et al., 1999; Hogan et al., 1999) but there is no evidence to confirm that exercise-induced increase in blood flow will facilitate as well PCr resynthesis. This is because the exercising muscle during active recovery may use this oxygen for other metabolic actions ecxept to PCr resynthesis (i.e. lactate oxidation, ATP recycling for exercise).The importance of adequate blood flow has been shown when local occlusion of muscle blood flow inhibites the PCr resynthesis and lactate removal (Trump et al., 1996; Sahlin et al., 1979). The effect of active compared to passive recovery on some of the important metabolites involved in muscle performance during sprinting are discussed in the following section. A flow chart of events that theoretically take place during active recovery are summarized in Figure 1.

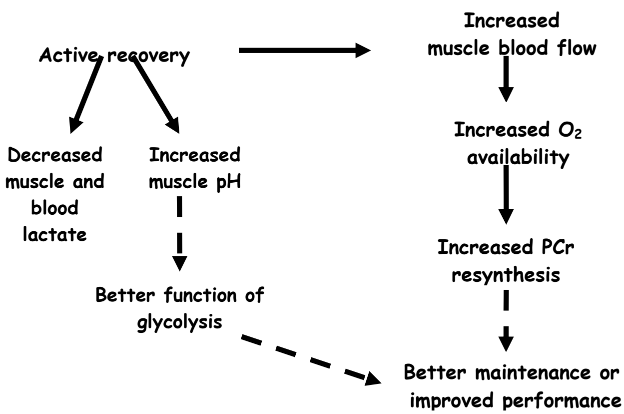

Figure 1. A hypothetical chain of events that may occur after active recovery between sprints. The discontinuous line indicates unproven effect

EFFECTS OF ACTIVE RECOVERY ON MUSCLE H^+ AND LACTATECONCENTRATION, PCR AND GLYCOGEN

The effects of active recovery on blood lactate removal are well documented. However, a limited number of studies have used muscle biopsies to examine the changes of muscle lactate and other metabolites or substrates such as PCr and muscle glycogen, during active compared to passive recovery following repeated exercise bouts (Spencer et al., 2006, 2008; McAinch et al., 2004; Bangsbo et al., 1994; Fairchild et al., 2003; Choi et al., 1994; Peters-Futre et al., 1987). The changes in the rate of recovery of selected metabolites may have an impact on performance during short or long duration sprints. This impact may be different (positive or negative) depending on the intensity or the duration of active recovery. Following a sprint, muscle lactate will increase while muscle glycogen, pH and PCr will decrease. The magnitude of these changes is related to sprint duration, the number of sprints as well as the interval between sprints. Whatever the case, despite a fast PCr resynthesis, muscle pH, muscle lactate and muscle glycogen restoration may take several minutes or hours. Active or passive recovery after a sprint may change the rate of replacement of these metabolites.

Muscle pH and Lactate after Active and Passive Recovery

The muscle homeostasis has been shown to recuperate faster as a response of active recovery (Sairyo et al., 2003) although this has not observed in all studies (Bangsbo et al., 1993, 1994). These studies used leg extension (Bangsbo et al., 1993, 1994) or wrist flexion (Sayrio et al., 2003) as exercise modes (different from commonly used human locomotory activities) and measured changes of muscle pH with muscle biopsies and magnetic resonance spectroscopy respectively. Nevertheless, their findings are in contrast, since muscle pH after active compared to passive recovery was unchanged during leg extension but increased during wrist flexion exercise (Bangsbo et al., 1994; Sayrio et al., 2003). Furthermore, any comparison between studies is difficult because different active recovery modes were used (progressively decreased intensity, constant intensity). While there is no strong evidence for a faster muscle pH restoration, this fact cannot be excluded.

Muscle lactate has been shown to decrease after 10 minutes of active compared to passive recovery (Bangsbo et al., 1994). However, there are reports of higher (Peters-Futre et al., 1987) or unchanged (Choi et al., 1994; McAinch et al., 2004; Fairchild et al., 2003) muscle lactate concentration following long duration of active recovery (15 to 60 min). Higher muscle lactate after active recovery has been reported following repeated short duration sprints (Spencer et al., 2006). Although the results concerning the muscle lactate and pH changes after active recovery are limited, it is obvious that this issue is critical for performance on a subsequent exercise bout and needs further examination.

PCr Resynthesis after Active and Passive Recovery

Restoration of PCr is of vital importance for performance in a subsequent sprint (Bogdanis et al., 1995). The PCr resynthesis starts immediately after the cessation of a sprint bout and is dependent on a number of factors (for review see McMahon and Jenkins 2002). Briefly, PCr resynthesis is an oxygen dependent process (Haseler et al., 1999) which is also affected by muscle H^+ concentration (Sahlin et al., 1979). Therefore, any factor that may interfere with oxygen availability and muscle pH will affect the rate of PCr resynthesis. It has been shown that active recovery decreases muscle oxygenation (decreased oxygen contend of myoglobin) and leads to increased levels of deoxyhaemoglobin (Dupont et al., 2007; Buchheit et al., 2009). In this case, it is not surprising that a lower percentage of PCr was restored immediately after and 21 s later following a set of 6x4 s sprints (Spencer et al., 2006). Immediately after the sprint repetitions, only 32% of PCr was resynthesized following active recovery while 45% of PCr was restored following passive recovery. Twenty-one seconds after the end of the last sprint, PCr was 55% of the resting levels when recovery was active compared to 72% when recovery was passive. Although these differences were not statistically significant, they showed a trend towards an impairment of PCr resynthesis after active recovery (Spencer et al., 2006). It is likely that the mitochondrial oxygen demand during active recovery decreases the oxygen available for PCr resynthesis. Notably, PCr stores are lower after active recovery compared to passive recovery not only after short duration but also after long interval duration (McAinch et al., 2004).

The effects of different intensities of active recovery were studied following the experimental protocol described previously (i.e. 6x4 s sprints with 21 s interval; Spencer et al, 2008). Unfortunately muscle biopsies were not taken after passive recovery; nevertheless, both active recovery intensities which were studied corresponded to 20 and 35% of VO_2max and showed the same changes in PCr content following the 6x4 s sprints (Spencer et al., 2008). In addition, it should be noticed that muscle oxygenation was not different when active recovery of 20 or 40% of VO_2max was used during a short interval period of 15 s between sprints (Dupont et al., 2007). The absence of differences between active recovery-intensities may be attributed to the lower efficiency observed during cycling at very low workloads (Smith et al., 2006; Ettema and Lorås 2009). Thus, a lower efficiency at very low intensities used for active recovery may mask any effect of active recovery-intensity on the PCr content. Furthermore, it is likely that the rate of PCr resynthesis is slower in type II compared to type I muscle fibers (Casey et al., 1996) and type II fibers are depleting the PCr stores faster than the type I fibers (Greenhaff et al., 1994). Because of these differences between fiber types, it is likely that type II fibers may be more prone to the impairment of PCr resynthesis. These fibers are mainly activated during short duration sprints performed with fast rate of muscle actions, such as those performed in the above-mentioned studies. However, this hypothesis has not been tested after active recovery.

A possible concurrent use of oxygen for lactate oxidation and for muscle contractions during active recovery may prevent the oxygen needed for a fast PCr resynthesis. Under these conditions, PCr may be lower after active compared to passive recovery of short or long duration. This may affect type II more than type I muscle fibers and probably will decrease performance when a short interval is provided.

Muscle Glycogen after Active and Passive Recovery

A significant reduction of muscle glycogen occurs after single and repeated high intensity sprints of short or long duration (Gaitanos et al., 1993, Bogdanis et al., 1995, Hargreaves et al., 1998). The replenishment of muscle glycogen starts after a sprint and an increased rate of muscle glycogen restoration has been reported after cessation of exercise following passive recovery (Pascoe and Gladden 1996). Muscle glycogen can be partly replenished during the recovery period, without the availability of any exogenous carbohydrate source (i.e. fluids or food), using the lactate as a substrate. Glycogen can be replenished either using lactate directly as a source or after conversion of lactate to glucose (Fournier et al., 2004). The rate of refilling of glycogen stores is higher after high intensity compared to low intensity exercise probably because of the higher lactate availability following high intensity exercise.

The lactate during recovery is either converted to glycogen or oxidized during active recovery (Hermansen and Vaage 1977, Brooks and Gaesser 1980). However, the fate of lactate following active recovery may be an important issue, since an increased rate of lactate oxidation, which probably takes place during active recovery, may reduce the substrate availability for glycogen replenishment within the muscle. Early reports have shown no different rates of muscle glycogen replenishment after 45 min of active or passive recovery following high intensity exercise (5x90 s bouts at intensity of 120% VO_2max; Peters-Futre et al., 1987). Later studies observed a decreased rate of glycogen restoration when the participants followed partially active (30 min active plus 30 min passive recovery) compared to 60 min of passive recovery (Choi et al., 1994). These findings were confirmed by recent studies, however, the decreased muscle glycogen restoration was limited to the slow type I muscle fibers, while the fast contracting type II fibers were not affected (Fairchild et al., 2003).

It should be considered that the impaired muscle glycogen restoration was observed following long duration active recovery periods (i.e. 30-45 min; Choi et al., 1994; Fairchild et al., 2003). It is uncommon to use such a long duration of active recovery during training or following a training session. The duration of active recovery commonly used in practice (i.e. about 15 min) may not impair muscle glycogen replenishment. For example, no difference on muscle glycogen content was observed when active recovery at intensity 40% of VO_2 peak was applied for a period of 15 min (McAinch et al., 2004) or after 10 minutes of one leg active recovery (Bangsbo et al., 1994). Coaches are advised to follow shorter than 15 min of low intensity active recovery in order to avoid any decrement in the rate of glycogen resynthesis. A fast glycogen resynthesis is important to maintain a high glycogen content before the start of the next high intensity event or training session.

Active Recovery and Restoration of Performance

Active Recovery versus Passive Recovery between Short Duration (4 to 30 s) Sprints

Sprints of very short duration (2 to 4 s) are frequently used during team sports, while sprints of 5 to 30 s appear during individual competitive sports. In addition, training sessions of many sports include activities of this duration performed with a maximum intensity. These sprints may be performed with different intervals depending on the training purpose. In this case, it is possible that the changes in performance with successive bouts will be affected by active recovery within the interval.

Performance in cycling and running sprints

Early studies used repeated sprint protocols to examine the effects of active recovery on performance. The studies of Signorile et al., (1993) and Ahmaidi et al., (1996) showed that active recovery could be beneficial to performance. Signorile et al., (1993) applied a set of 8x6 s cycling sprints with a 30 s interval. Mean power was better after active recovery compared to passive recovery. Similarly, performance was improved when the same duration sprints (6 s) were applied with a 5 min interval; especially during sprints with a high resistive load (i.e. 6 kg; Ahmaidi et al., 1996). However, a cycling protocol applying 10x10 s sprints with 30 s intervals demonstrated no significant difference in mean and peak power after active or passive recovery (Matsushigue et al., 2007). A repeated sprint protocol with short duration sprints that simulates team-game sprint duration has been applied (6 repetitions of 4 s sprints with 21 s interval) and has also been tested after active recovery. Nine male moderately trained individuals followed this protocol during cycling sprints in the study of Spencer et al., (2006). The total work produced was not different after active or passive recovery; although peak power decreased more during the last sprints in the active recovery trial (Spencer et al., 2006). Similarly, using the same protocol in team sport athletes, it was found that peak power was reduced after active compared to passive recovery although no differences in total work (3.9% less after active recovery; Spencer et al., 2008) were observed.

The same protocol of 6x4 s sprints was applied in 10 male individuals during running on a non-motorized treadmill. Buchheit et al., (2009) found that active recovery, corresponding to 45% of the individual vVO_2max, applied during the 21 s interval decreased the running speed (active recovery: 3.79±0.27 vs. passive recovery: 4.09±0.32 $m \cdot s^{-1}$) and stride frequency. A clear negative effect of active recovery was demonstrated when sixteen basketball players participated in a field study and performed 10x30 m shuttle running sprints with short interval duration (i.e. exercise to interval ratio 1:5; Castagna et al., 2008). The basketball players participated in the last study showed an increased fatigue index and average running time when active compared to passive recovery was applied during the 30 s intervals between the 30 m sprints (fatigue index 5% vs. 3.4%; average running time 6.32 s vs. 6.17 s).

When comparing running to cycling exercise, the decrement of performance after active recovery is more evident in running. This was observed during the same protocol applying a work to interval ratio of 1:5. The participants in the above-mentioned studies (Spencer et al., 2006, 2008; Buchheit et al., 2009) had a similar training and fitness status (moderately trained, VO_2max: 53-55 $ml \cdot kg^{-1} \cdot min^{-1}$). Although recovery between sprints may be related not only to VO_2max but also to other aerobic fitness index (Bogdanis et al., 1995), the different response to active recovery during cycling (improved or no different performance after active compared to passive recovery) compared to running (decreased performance after AR) protocols is not easy to explain.

Time is important, not only for the duration of a sprint, but also for the recovery interval. When a short interval is applied between sprints of 15 to 30 s, the effects of active recovery on fatigue are much clearer. This has been shown in the study of Dupont et al. (2007) when a 30 s cycling sprint was performed after a 15 s sprint with a 15 s interval of either active or passive recovery between sprints. Mean and peak power was significantly reduced after active recovery compared to passive recovery (Dupont et al., 2007). In contrast, when long interval duration is applied between 15 to 30 s sprints, it seems that active recovery may have a beneficial effect. For example, active recovery applied during a 4 min interval between two 30 s sprints improved mean power output by 3% compared to passive recovery (Bogdanis et al., 1996). Similarly, a better maintenance of mean power was reported by Connolly et al. (2003) during 6x15 s sprints performed when the participants were cycling at 80W during the 3 min interval period between sprints. The improved performance after active recovery compared to passive recovery in the studies of Bogdanis et al. (1996) and Connolly et al. (2003) was confirmed by Spierer et al. (2004) in trained and untrained individuals during repeated 30 s sprints with a 4 min interval. It is interesting to note that in the study of

Spierer et al. (2004) the total work increased in both groups after active recovery, although the mean power increased after active recovery in the untrained but not in trained participants.

Performance in swimming sprints

Studies applied active recovery between repeated swimming sprints and have shown that irrespective of the interval duration, performance decreased after active recovery compared to passive recovery. Three studies have consistently found decreased performance during a set of 8x25 m sprints applied with 45 or 120 s intervals in recreationally trained (Toubekis et al., 2005), well-trained (Toubekis et al., 2006) and sprint-trained swimmers (Toubekis et al., 2010). However, when a 50 m sprint was applied 6 min following the 8x25 m sprints, performance was unaffected by active or passive of recovery (Toubekis et al., 2005; Toubekis et al., 2006; Toubekis et al., 2010). Combining the results of the last three studies we showed that sprint-trained compared to untrained swimmers were less affected by active recovery at an intensity 60% of the 100 m when the interval between sprints was 120 s, although both groups decreased performance after active recovery (rest to interval ratio 1:10; effect size: sprint-trained=0.3, untrained=0.6; Figure 2). However, well-trained swimmers (mixed group of sprint and endurance trained swimmers) showed no difference with untrained swimmers in their reaction to active recovery when the 25 m sprints were performed with 45 s intervals (Figure 2).

It is interesting to note that half of the sprint-oriented swimmers swam faster by 1.2% while the other half swam 3.2% slower in a 50 m sprint performed 6 min following the set of 8x25 m sprint (effect size=0.1). It seems that training status and/or the interval duration are important parameters when active recovery is applied between sprints, while inter-individual resposnses should be also be considered when this practice is used. In another study, two sets of repetitions were applied to simulate high intensity swimming training (Toubekis et al., 2008). The first set consisted of standard work of 4x30 s tethered swimming bouts at intensity 154% of the VO_2max. This set was followed by 4x50 yard repetitions starting every 2 min (~90 s interval). It is interesting to note that when active recovery was applied during the 5 min interval between two sets of repetitions, a tendency for improved performance was observed in the second set of repetitions (Toubekis et al., 2008). In contrast, performance was decreased when active recovery was applied during the interval time between repetitions of the second set (4x50 y).

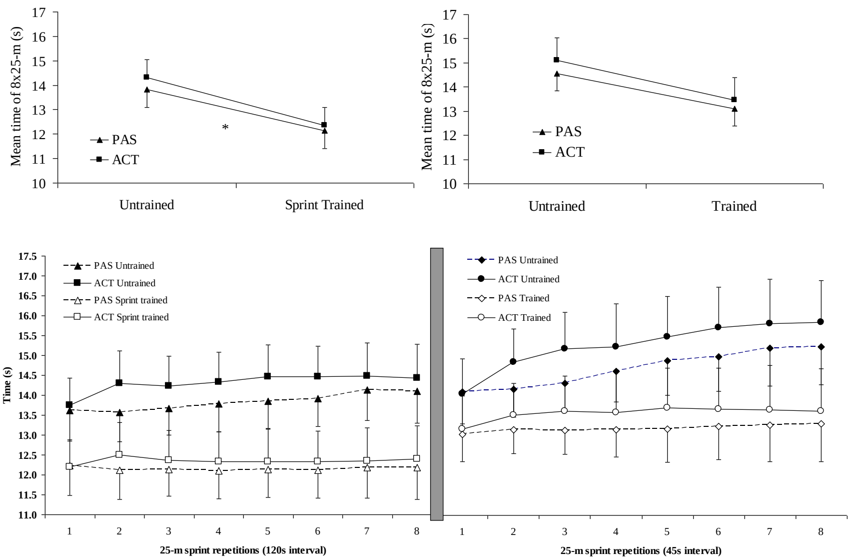

Figure 2. Upper panel: Mean time of 8x25 m sprints in untrained swimmers compared to sprint-trained and well-trained swimmers (120 s interval – left; 45 s interval - right). Lower panel: Performance time during the 8x25 m sprints was performed either with a 120 s (left) or with a 45 s (right) interval. A greated performance decrease was observed after active recovery in untrained compared to sprint-trained with 120 s interval but no different response was observed between well-trained and untrained when the interval was 45 s. *: sprint number vs. performance time interaction. See text for details. Data from Toubekis et al., (2005, 2006 and 2010)

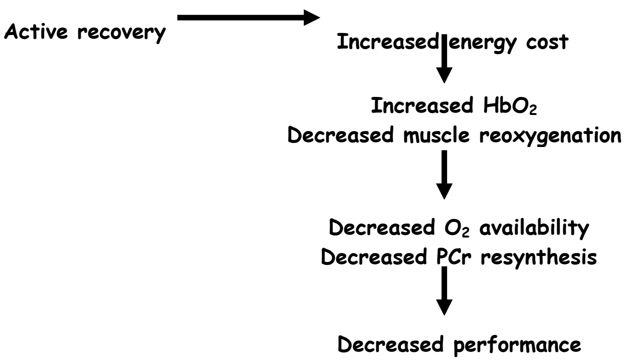

Figure 3. A schematic flow of events leading to decreased performance following active recovery between short duration sprints (4 to 30 s) with relatively short interval duration (exercise to interval ratio 1:3 to 1:5)

Table 1. Summary of studies comparing active versus passive recovery between repeated sprints of short duration (4 to 30 s) in different types of activities

Study	Participants	Type of exercise-tests	Intensity of active recovery	Performance Active versus Passive recovery
Cycling				
Matsushigue et al., 2007	15M	10x10 s I: 30 s	60W	PP:NS MP:NS MP < in sprint 2 with AR
Connolly et al., 2003	7M Recr	6x15 s I: 3 min	80W	PP and MP: NS
Spencer et al., 2006	9M, Mod VO_2max: 4.4 $l{\cdot}min^{-1}$	6x4 s I: 21 s	35% VO_2max	TW: NS 6th sprint PP < with AR
Spierer et al., 2004	3M, 3F Unt VO_2max: 36.9 $ml{\cdot}kg^{-1}{\cdot}min^{-1}$ 9M Mod VO_2max:45.6 $ml{\cdot}kg^{-1}{\cdot}min^{-1}$	Repeated 30 s (until power drop>70% of 1st) I: 4 min	28% VO_2max	MP > with AR in Unt MP: NS in Mod TW > with AR in both groups
Bogdanis et al., 1996	13M VO_2max:4.3 l/min	2x30 s I: 4 min	40% VO_2max	MP 2.3% > with AR
Ahmaidi et al., 1996	10M VO_2max:56.2 $ml{\cdot}kg^{-1}{\cdot}min^{-1}$	Repeated 6 s I: 5 min	32% VO_2max	MP > with AR
Signorile et al., 1993	6M	8x6 s I: 30 s	60W	MP > with AR

Table 1. (Continued)

Study	Participants	Type of exercise-tests	Intensity of active recovery	Performance Active versus Passive recovery
		Running		
Buchheit et al., 2009	10M VO_2max:55.1 ml·kg^{-1}·min^{-1}	6x4 s I: 21 s	~45% vVO_2max	Time > with AR Stride freq.< with AR
		Team-game activities		
Castagna et al., 2008	16M basketball players VO_2max:59.5 ml·kg^{-1}·min^{-1}	10x30 m (~6 s) shuttle runs I: 30 s	50% MAS	Time > with AR FI > with AR
		Swimming		
Toubekis et al., 2005	8M and 8F swimmers	8x25 m+1x50 m I: 45 or 120 s (25 m) I: 6 min (50 m)	60% 100-m	25 m Time > with AR 50 m Time: NS
Toubekis et al., 2008	8M swimmers VO_2max: 4.2 l·min^{-1}	4x30 s + 4x50-y I: 5 min (in sets) I:~90 s (in sprints)	60% 100-m	Time NS: with AR between sets. Time > with AR in 50y

MAS: maximal aerobic speed, I: interval, PP: peak power, MP: mean power, TW: total work, Recr: recreationally active, Mod: moderately trained, Unt: untrained, PR: passive recovery, AR: active recovery, NS: no significant difference between acteive and passive recovery, M: male, F: female.

The findings of the swimming studies support the argument that when a long duration interval (work to interval ratio 1:8 to 1:12) is applied, active recovery may be beneficial or have no negative impact on performance compared to passive recovery in sprints of about 15 to 30 s duration (Bogdanis et al., 1996; Connolly et al., 2003; Spierer et al., 2004; 50 m sprints, Toubekis et al., 2005, 2006, 2008).In contrast, performance during 4 to 10 s sprints has been shown to decrease after active recovery compared to passive recovery when a work to interval ratio of 1:3 to 1:5 is applied (Spencer et al., 2006, 2008; Dupont et al., 2007; Buchheit et al., 2009; Castagna et al., 2008). An exemption is the study of Signorile et al. (1993) who found increased performance after repeated 6 s sprints applied with a 30 s interval. In Figure 3, the physiological events that may lead to decreased performance during repeated sprint with short interval duration are summarized. Other factors such as the mode of exercise, the training status of the participants or the intensity of active recovery may be contributing factors. The issue of intensity of active recovery will be discussed later in this chapter. The studies which examined the effects of active recovery compared to passive recovery on performance are presented in Table 1.

Active versus Passive Recovery between Long Duration (40 to 120 s) Sprints

Performance in swimming sprints

The majority of studies that have examined the effects of active recovery versus passive recovery on performance during long duration sprint exercise have shown similar results. McMurray (1969) reported no differences after different modes of passive recovery compared to active recovery in performance of a 200-yard swim. In four different conditions, following a standard load exercise, the swimmers rested passively in an upright position, in supine, stood still in the water, or swum slowly during recovery before a 200-yard test (McMurray 1969). Besides this early study, further studies reported beneficial performance outcome after active recovery in different protocols using cycling or swimming. Surprisingly, no running studies have tested the effect of active recovery between sprints of 40 to 120 s duration so far. During competitions, swimmers may be asked to participate in repeated races with an interval duration of 10 to 30 minutes. It is advised that during the interval period they should follow active recovery since experimental evidence suggests that this practiceis beneficial (Felix et al., 1997; Greenwood et al., 2008; Toubekis et al., 2008a). Repetitions of 100 m and 200 yard swimming may be performed faster when active recovery rather than passive recovery is applied during a 10 to 15 min interval (Felix et al., 1997; Greenwood et al., 2008; Toubekis et al., 2008a). The effective intensity of active recovery during the above studies was reported corresponding to 100 or 200-y best time (i.e 60% of the 100-m, 65% of the 200-yard; Toubekis et al., 2008a; Felix et al., 1997) or the lactate threshold (Greenwood et al., 2008).

Performance in cyclingsprints

Exercise at intensity 120 to 130% of VO_2max can be sustained for about 2 minutes before exhaustion. This intensity has been applied in the studies of Thiriet et al., (1993) and Dorado et al., (2004). Thiriet et al. (1993) reported improved performance when active recovery was used during the 20-min interval between 4x120 s bouts at an intensity 130% of the VO_2max. The beneficial effects on performance were evident after either arms or legs cycling active recovery (Thiriet et al., 1993). When four repetitions at an intensity 120% of VO_2max were performed until the participants were unable to maintain 70 rpm; active recovery applied during the 5 min interval improved performance by 3-4% compared to passive recovery (Dorado et al., 2004). Although the cycling bouts were performed up to exhaustion, the duration of each bout was not reported in the last study. Nonetheless, inspection of figure 3 of the paper reveals a time range from ~40 to ~120 s (Dorado et al., 2004). During sprints of this duration, aerobic contribution becomes more important with successive sprints (Bogdanis et al., 1996a). As the authors discussed an increased aerobic contribution and increased oxygen kinetics was the main reason for improved performance after active recovery compared to passive recovery (Dorado et al., 2004). The performance results reported in the above-mentioned studies are in agreement with previous findings of Weltman et al. (1977) who reported improved number of pedal revolutions despite no differences in mean power when active recovery was applied between two 60 s sprints after a 10 and 20 min interval. However, when a short recovery period (work to rest ratio 1:2.5) was used during repeated ice skating sprints, the distance covered during a series of 7x40 s repetitions was similar after active or passive recovery (Lau et al., 2001). The ice hockey players participated in the last study performed 7x40 s sprints with 90 s interval and repeated the same set of repetitions after a 15 min interval which included 12 minutes of self-selected cycling active recovery (Lau et al., 2001).

Table 2. Summary of studies using active versus passive recovery between repeated sprints of long duration (40 to 120 s) in different types of activities

Study	Participants	Type of exercise-tests	Intensity of active recovery	Performance Active versus Passive recovery
Cycling				
Dorado et al., 2004	10M, Recr	4x40 to 120 s at 120% of VO_2max to exhaustion I: 5 min	20% VO_2max	Performance AR > PR
Thiriet et al., 1993	16M Recr VO_2max: 45.3 $ml \cdot kg^{-1} \cdot min^{-1}$	4x120 s at 130% of VO_2max I: 20 min	30% VO_2max arms or legs	Performance AR > PR
Weltman et al., 1977	11M VO_2max: 42.9 $ml \cdot kg^{-1} \cdot min^{-1}$	2x60 s I: 10 or 20 min	60W	Pedal revolutions AR > PR
Game-sport activities				
Lau et al., 2001	18M Ice hockey players	2 x (7 x 40 s) I: 90 s I:15 min between sets	S-S Cycling at 50-70 rpm for 12 min	Distance skated: NS
Swimming				
Felix et al., 1997	10F	2x200 y I: 14 min	12 min at 65% of 200y	Performance 200 y AR 1.7% > PR
Toubekis et al., 2008a	5M, 6F	2x100 m I: 15 min	60% 100 m AR: 5 min AR:10 min	Performance 100 m 5 min AR > PR 10 min AR : NS
McMurray 1969	8M	5 min at 160 b/min + 200-y swim I: 3 min	HR range 118-126 b/min	200-y Time: NS

Recr: recreationally active, S-S: self-selected, PR: passive recovery, AR: active recovery, NS: no significant difference, I: interval duration, M: male, F: female.

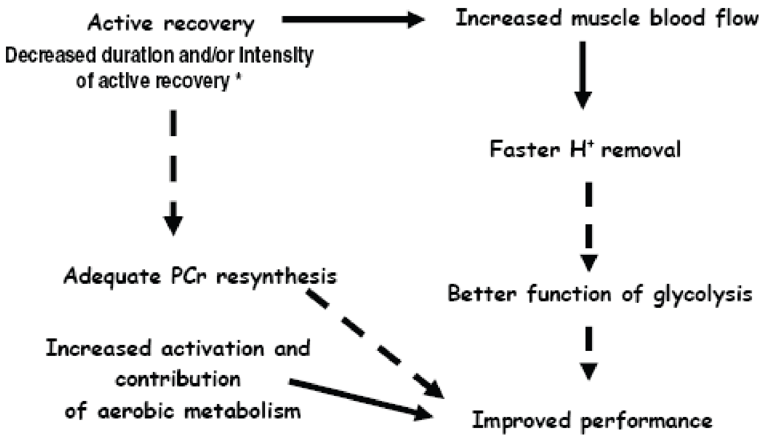

Figure 4. A schematic representation of a series of events that may act to improve performance after active recovery during long duration sprints (40 to 120 s). Discontinuous lines indicate effects that have not been proved yet. **indicate that a part of the interval is active recovery and the intensity as low as possible*

A summary of studies examined the effects of active versus passive recovery between 40 to 120 s sprints is shown in Table 2. It seems that active recovery is beneficial and maintains a better performance on subsequent bouts following sprints of long duration when a long interval is available (i.e. work to exercise ratio 1:10 to 1:15). However, important issues such as the intensity and duration of active recovery are still under research. The physiological factors that may contribute to increased performance after active recovery compared to passive recovery during long duration sprints are presented in Figure 4.

The effects of intensity of active recovery on sprint performance

The intensity of active recovery may be crucial for the performance outcome. Athletes should follow active recovery at a low energetic cost while at the same time muscle blood flow must be adequately increased. A low energetic cost may be necessary for a fast recovery of high energy phosphates while an adequate muscle blood flow is required for the removal of metabolic by-products. Recent studies examined the effects of different intensities of active recovery on performance. The intensity is expressed as a percentage of VO_2maxduring cycling and team-game activities (Dupont et al., 2007; Spencer et al., 2008; Maxwell et al., 2008) as a percentage of the best time or as a percentage relative to the lactate threshold during swimming (Toubekis et al., 2006; Toubekis et al., 2010; Greenwood et al., 2008). During the 21 s interval between 6x4 s sprints, both active recovery intensities were applied at 20 or 35% of the VO_2max and equally decreased peak power and total work compared to passive recovery in team-sport trained individuals (Spencer et al., 2008). Similarly, when active recovery intensities corresponding to 20 or 40% of the VO_2maxwere compared to passive recovery, both decreased performance in a 30 s sprint performed shortly (15 s) after a 15 s sprint (Dupont et al., 2007). It is possible that the short interval duration or the small difference between intensities of active recovery applied in the studies of Spencer et al. (2008) and Dupont et al. (2007) have masked the effects of active recovery. This may have also occurred during repeated 25 m sprints with a 45 s interval when the active recovery intensity was 50 or 60% of the 100 m velocity (Toubekis et al., 2006). Using longer interval duration (120 s) and a greater difference between active recovery intensities on the same repeated swimming sprint protocol, the results were different from previous studies (Toubekis et al., 2010). In that study the low and high intensity active recovery were estimated to correspond to 36% and 59% of the VO_2max (40% and 60% of the 100-m velocity). During passive recovery and active recovery at low intensity trials, performance was better compared to high intensity active recovery (Toubekis et al., 2010). However, in the repeated swimming sprint studies, performance of a subsequent 50 m sprint (duration ~30s) swum after six minutes, was unaffected by active recovery intensity (Toubekis et al., 2006; Toubekis et al., 2010). Therefore, it is likely that long interval duration (i.e. work to interval ratio 1:10 to 1:12) in combination with very low intensity of active recovery have a beneficial effect on performance compared to a high intensity active recovery.

A different approach to test the effects of swimming intensity during active recovery was applied by Greenwood et al., (2008). The authors calculated the velocity corresponding to the lactate threshold using a speed-lactate test and subsequently asked their swimmers to perform 2x200-yard sprints with a 10-min interval using passive recovery or active recovery. The active recovery intensities reported, were below, above or at the lactate threshold. It is interesting to note that performance during the second 200 yard sprint was improved not only compared to passive recovery but also compared to the first 200 yard sprint after active recovery at a velocity corresponding to the lactate threshold (Greenwood et al., 2008). It should be noted however, that the lactate threshold velocity can be calculated using different methods and readers should be aware that no single method can be used as a gold standard (Tokmakidis et al., 1998).

During game-sports activities, it has been shown that low intensity is beneficial compared to high intensity of active recovery (35 vs. 50% of VO_2max) allowing a 3% better peak power during repeated 5 s cycling sprints (Maxwell et al., 2008). These 5 s sprints were performed within 20x2-min blocks. Within each 2 min block, a 10 s standing, 5 s sprint and 105 s of active recovery were performed (Maxwell et al., 2008). During a different protocol applied by Del Coso et al. (2010), the mean power output during a 4 s cycling sprint was not different after intermittent sets performed with different active recovery intensity and different interval duration but with equal energy expenditure.

In summary, it seems that very low intensity combined with a long interval duration (exercise to interval ratio 1:10) may maintain performance similar to passive recovery during short duration sprints. In contrast, active recovery intensity at the lactate threshold velocity, which is still very low intensity, may be beneficial not only to maintain but in some cases may improve performance on a subsequent sprint of 60 to 120 s duration.

The effect of exercise mode during active recovery

Few studies applied a different mode of exercise during the sprint compared to that applied during active recovery. For example, Siebers and McMurray (1981) tested a 200 yard swim after a 15-min interval following a 2-min standard tethered swimming exercise at intensity 90% of VO_2max. The study included two experimental conditions with active recovery walking or swimming. During the 15-min interval, swimmers either walked on the pool-deck (velocity 2.5 to 3 mph) or swum at self-selected intensity (moderate pace) for 10 minutes and then rested passively for the remaining 5 min. A limitation of this study was that the intensity of exercise was not specified. No difference was observed in the 200-yard swim although swimmers were 1% faster after swimming active recovery (Siebers and McMurray 1981). Swimming or rowing active recovery was applied during the 14-min interval between two 200 yard sprints (Felix et al., 1997). The active recovery intensity corresponded to the 65% of the 200 yard velocity and to the 60% of the maximum heart rate for rowing and performed for 10 minutes within the 14-min interval period. Swimming times of the second 200 yard sprint were similar after swimming or rowing active recovery and both were faster compared to passive recovery condition (Felix et al., 1997). Active recovery at the same relative intensity with arms or legs (30% of the VO_2max) was applied in the study of Thiriet et al., (1993). Both modes of active recovery improved performance compared to passive recovery (Thiriet et al., 1993).

It seems that the mode of active recovery is not critical for the performance outcome on a subsequent bout at least when a long interval is provided and the tested exercise bout is a long duration sprint (i.e. ~120 s). A summary of studies which examined the effects of the intensity of active recovery or different modes of active recovery on performance are shown on Table 3.

The effects of active recovery duration on performance

When several experimental protocols apply active recovery between repetitions, there is a need to stop the participant for blood sampling. Thus, part of the interval between sprints is passive recovery and the remaining is active. This means that although the recovery is characterized as active, in fact, it is partially active and partially passive. The extent of this passive rest period within an active interval may affect the recovery process. In the studies of Felix et al., (1993), Siebers and McMurray (1981), Toubekis et al. (2008), during active recovery conditions, almost 1/3 of the interval was passive recovery. Only one study has examined the effects of active recovery duration on performance. Toubekis et al. (2008a) found that when a 15-min interval is provided, a 5-min active recovery was appropriate to enhance performance compared to a 10-min active and 15-min passive recovery. In the study of Del Coso et al. (2010), the different duration of active recovery of 4.5, 6 or 9 min, was designed to demand the same energy expenditure applying intensities corresponding to 24, 18 or 12% of the respiratory compensation threshold. Despite the differences in duration and intensity of active recovery, the performance on a subsequent 4 s sprint was not different between conditions. It is likely that a combination of active and passive recovery may be beneficial between long duration sprints, and the appropriate duration of active recovery which may also depend on the intensity and duration of the tested sprint remains to be examined.

Active recovery during various types of exercise

Despite performance time, mean power, peak power and total work measured in most of the studies, there are other specific sport abilities that should be examined after active recovery compared to passive recovery. The evaluation of isometric muscle force and muscle torque during isokinetic contractions are important parameters for specific sports performance. Several studies examined the force and isokinetic muscle function after active or passive recovery. Following a 60 s maximum exercise at 150% of VO_2max, active recovery (cycling at 30 % of VO_{2max}) or passive recovery had no positive or negative effect onpeak torque and total work of the dominant quatriceps during 60 repetitions (~90 s) performed at an angular velocity $150^{o}\cdot s^{-1}$ (Bond et al., 1991). In contrast, the maximum torque measured at an angular velocity of $60^{o}\cdot s^{-1}$ was increased after 15 minutes of active recovery at 30% but not after active recovery at 60% of the VO_2max(McEniery et al., 1997).

The maximum voluntary contraction (MVC:isometric force) was measured after low intensity (50% of MVC) isometric contraction to fatigue and improved after a 5-min active recovery cycling at 10W (60 rpm) compared to passive recovery (Mika et al., 2007). Furthermore, the isometric hand-grip force, which may be important for climbing, was reduced during the 30 minutes after a climbing trial (Watts et al., 2000). The reduction in isometric hand-grip force was significantly greater one minute after the trial when the climbers applied recumbent cycling at 25W as active recovery compared to passive recovery (Watts et al., 2000).

Partially active recovery (5 min active plus 5 min passive) was applied during the 10-min interval separating the six competitive men's gymnastics events (floor, pommel, rings, vault, parallel bars, horizontal bar), and this practice helped the participants to achieve higher scores compared to passive recovery (Jemni et al., 2003). The different protocols applied and the limited number of studies where the isometric muscle force or muscle torque was examined do not allow us to reach a firm conclusion concerning the effectiveness of active recovery on muscle function. Further research is needed to examine the efficacy of active recovery under specific sport conditions. A summary of the findings concerning muscle function and specific sport activities ispresented in Table 4.

Active Recovery Following a Game or Training Session and Performance

Performance in team sports

Athletes are advised to follow a cool-down practice after a high intensity training session or after competition. The main reason for this practice is to enhance the lactate removal and recovery of homeostasis. It is believed that this will facilitate the recovery of performance before the next session. However, active recovery following a training session may not offer any advantage for performance (Barnett, 2006).

Table 3. Effects of different intensities or different types of active recovery compared to passive recovery during repeated sprints in various types of exercise

Study	Participants	Type of exercise-tests	Intensity of active recovery	PerformanceActive versus Passive recovery
Cycling				
Spencer et al., 2008	9M team sport athletes VO_2max:3.8 $l \cdot min^{-1}$	6x4 s I: 21 s	20 or 35% VO_2max	PP and TW: NS between ARs PP< with ARs
Dupont et al., 2007	12 M soccer players	15 and 30 s I:15 s	20 or 40% VO_{2max}	MP: NS between ARs MP< with ARs
Del Coso et al., 2010	11M VO_2max: 3.7 $l \cdot min^{-1}$	4x90 s sprints at 163% of the RCT. 4 s sprint before and after the 4x90 s	24, 18, 12% of the RCT for 4.5, 6, 9 min	MP: NS with ARs
Team-game activities				
Maxwellet al., 2008	8M	20x2 min cycling (10 s rest-5 s sprint-105 s AR)	35 or 50% VO_2peak	PP > with the lower AR intensity
Swimming				
Toubekis et al., 2006	9M swimmers VO_2max: 65.1 $ml \cdot kg^{-1} \cdot min^{-1}$	8x25 m + 50 m I: 45 s (25 m) I: 6 min (before 50 m)	50 or 60% 100 m	25-m Time: NS between ARs, 25-m Time > after ARs vs. PR
Toubekis et al., 2010	10M swimmers	8x25 m + 50 m, I:120 s (25 m) I: 6 min (before 50 m)	40 or 60% 100 m	25-m Time: NS PR and AR at 40%. 25-m Time> AR at 60% vs PR

Table 3. (Continued)

Study	Participants	Type of exercise-tests	Intensity of active recovery	Performance Active versus Passive recovery
Greenwood et al., 2008	14M swimmers	2x200 m I: 10 min	i) LT ii) below LT iii) above LT	200-y Time < after LT-AR
Siebers and McMurray 1981	6F swimmers	2 min 90% of VO_2max followed by 200 y swim I: 15 min	i) S-S: 10 min walk + 5 min sit ii) S-S: 10 min swim + 5min sit.	200-y Time: NS between ARs (1% faster 200-y after swim recovery)
Felix et al., 1997	10F swimmers	2x200 y I: 14 min (2 min PR + 10 min AR + 2 min PR)	i) swim 65% of 200 y ii) rowing at 60% of HRmax	200-y Time < with swimming and rowing ARs

I: interval duration, RCT: respiratory compensation threshold, PP: peak power, MP: mean power, TW: total work, ARs: All Active Recovery conditions, PR: passive recovery, AR: active recovery, LT: lactate threshold, S-S: self-selected, NS: no significant difference, HRmax: maximum heart rate, M: male, F:female.

Table 4. Effects of active recovery following various types of athletic activities

Study	Participants	Type of exercise-tests	Intensity of active recovery	Performance (AR vs. PR)
Mika et al., 2007	10M	Leg extension and flexion 3 x 50% of MVC with 30 s interval. MVC tested 5 min later	Cycling 10W at 60rpm	MVC > after AR Time to sustain 50% of MVC: NS
Watts et al., 2000	8M in the AR group 7M in the PR group	Wall climbing Duration 2.57 min. Hand grip measured 1, 10, 20, 30 min post climbing	Cycling at 25W recumbent	Hand grip < 1 min after climbing with AR
Jemni et al., 2003	12 M gymnasts	All Gymnastic apparatus, 10 min interval between	5 min passive + 5 min active self selected, below AT	Improved performance score with AR
Bond et al., 1991	5M	60 s sprint at 150% of VO_2max 20 min recovery followed by isokinetic evaluation 60 repetitions (~90s)	30 % VO_2max	NS: AR vs. PR
McEniery et al., 1997	4M, 1F	4x30 s sprints with 4 min interval, followed by 15 min recovery. Isokinetc strength at 1, 6 11, 16 min of recovery	30 or 60% of peak VO_2, self selected cadence	Max torque> after AR at 30% compared to PR

MVC: Maximum voluntary contraction (isometric), NS: no significant difference, AR: active recovery, PR: passive recovery, AT: anaerobic threshold, M: male, F: female.

More recent studies have investigated the effectiveness of active recovery immediately after a training session on performance before the next session. Tessitore et al. (2007) and Tessitore et al. (2008) examined the effects of different modes of 20 min active and passive recovery following a soccer training session and following futsal soccer games on performance 5 hours later. It was found that performance on several anaerobic tests such as the squat-jump, the countermovement jump, bounce-jump and 10 m sprint time were not affected by the mode of recovery, which included dry-land or water-based active recovery, electrostimulation, or passive rest (Tessitore et al., 2007, 2008). It is likely that the training stimulus was moderate and the recovery process of these athletes following training or competition was well-designed (players followed proper hydration and nutrition) and these may have masked any effect of the recovery interventions.

A study applied with international level female soccer players extended the performance testing 69 hours following a friendly game between national teams (Andersson et al., 2008). Active recovery was applied 22 and 46 hours following the match and included 60 minutes of low intensity cycling and low intensity resistance training (60% of HRmax; <50%1RM). Performance during a 20-m sprint, countermovement jump and isokinetic strength were not different following either active or passive recovery (Andersson et al., 2008). Similar results were obtained by King and Duffield (2009) in female netball players after a session including various sport specific activities. Fifteen minutes of active recovery at an intensity of 40% of the velocity at VO_2max (vVO_2max) or passive recovery showed similar effects on performance during five vertical jumps height and five 20-m sprints time both tested before a second session 24-hours later (King and Duffield 2009). The total stress imposed to the athletes during these non-controlled game-sport conditions is high enough to cause fatigue. Probably the active recovery applied after training session or a match is not appropriate to enhance performance recovery of selected tests in well-trained players. However, the effect of active recovery on the next training session on the overall game performance has not so far examined.

Performance in individual sports

During a laboratory setting, it is possible to control the load applied on the subjects. A controlled high intensity cycling protocol was applied by Lane and Wenger (2004) to examine the effects of several types of recovery on performance 24 hours later. Ten active males performed a series of 22 sprints ranging in duration from 5 to 15 s all applied with a work to rest interval 1:5.

Following this high intensity session, the participants followed a 15-min massage, cold water immersion, active recovery at an intensity of 30% of VO_2max and passive recovery on four experimental conditions. Performance measured in the same 22 sprints 24 hours later was maintained in all recovery conditions (massage, cold water immersion, active recover) but was reduced after passive recovery (Lane and Wenger 2004).

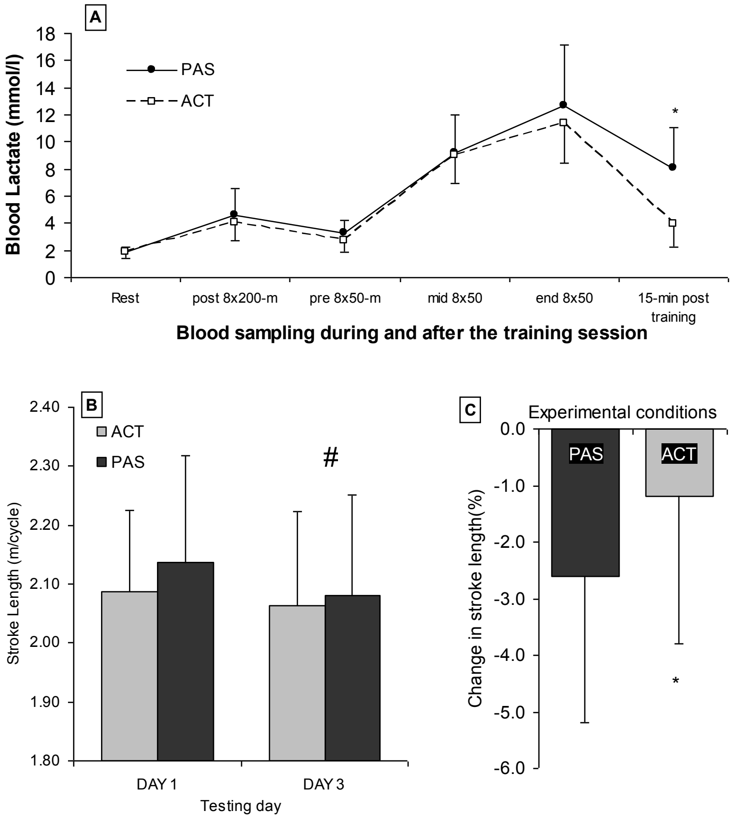

Figure 5. Blood lactate changes (panel A) during the training session followed either by passive or active recovery. Changes in stroke length (panel B) and percentage changes in stroke length (panel C) the days before (DAY 1) and the day after (DAY 3) the training session. * indicate $p<0.05$ between ACT and PAS conditions, # indicate differences between DAY 1 and DAY 3. (Data from Tsami et al., 2006; Reproduced with permission)

Table 5. The training content followed during the study of Tsami et al., (2006)

Warm up	1. 200-m freestyle 2. 2x200-m individual medley, swimming drills 3. 200-m choice
Main part of training	4. 200-m arms only swimming 5. 200-m legs only swimming 6. 8X200-m front-crawl (95% of the Critical Velocity; 25 s rest) 7. 300-m legs only swimming 8. 8x50-m [performed as 2x(4x50-m)] max effort starting every 2 min
Recovery	15 min of active or passive recovery

Table 6. The effects of active recovery applied after a training session or competition on performance during the following session or the following day

Study	Participants	Type of exercise-tests	Intensity of active recovery	Performance (AR vs. PR)
Andersson et al., 2008	17F soccer players	Two Soccer games within 72 hours Tests: 20-m sprint and CMJ	45% VO_2max (20 min)	NS
King and Duffield (2009)	10F netball players	Netball game simulation on two subsequent days. Tests: VJ and 20-m sprint	40% VO_2max (15 min)	NS
Lane and Wenger (2004)	10M	22 cycling sprints: 12x5 s, 6x10 s , 4x15 s. interval 25 s, 50 s, 75 s	30 % VO_2max (15 min)	MP: Maintained with AR. Decreased with PR

Table 6. (Continued)

Study	Participants	Type of exercise-tests	Intensity of active recovery	Performance (AR vs. PR)
Tessitore et al., 2007	12M soccer players	SJ, CMJ, BJ, 10 m sprint, before a morning and afternoon soccer training sessions (5-hours break)	20 min of AR in water or land movements vs. PR	NS
Tessitore et al., 2008	10M futsal players, VO_{2max}: 52.2 $ml \cdot kg^{-1} \cdot min^{-1}$	SJ, CMJ,10 m sprint, before and after a game and 5 hours latter	20 min of AR in water or land movements vs. PR	NS
Tsami et al., 2006	4M, 6F swimmers	High intensity swimming training. Tests: 400 m sumbaximal 50 m maximum	15 min AR at 60% of the 100 m velocity	400 m: SL maintainance after AR

MP: mean power, CMJ: countermovement jump, VJ: vertical jump, SJ: squat jump, BJ: bounch jump, SL: stroke length, F: female, M: male, AR: active recovery, PR: passive recovery, NS: no significant difference after active or passive recvery.

In addition to cycling, swimming training intensity can be precisely controlled in the field (swimming pool). The effects of active or passive recovery were studied after a high intensity training session in young swimmers (Tsami et al., 2006). The swimmers completed a training session including high intensity aerobic and anaerobic contents (see Table 5). The day before training and the day after training, swimmers performed a 50-m maximal and a 400-m sumbaximal (85% of the best time) test for the evaluation of metabolic and temporal parameters (stroke rate and stroke length). Fifteen minutes of active recovery at a pace corresponding to 60% of the 100-m velocity were applied immediately after the training session and helped to maintain a higher stroke length compared to passive recovery on the 400-m sub-maximal test but had no effects on the maximum intensity 50-m sprint time the day after training (Figure 5; Tsami et al., 2006). The results from studies in individual sports are not conclusive but support the use of a 15-min low intensity active recovery following a training session. A summary of studies using active recovery after a training session or competition are shown in Table 6.

CONCLUSION

Active recovery compared to passive recovery is strongly associated with greater metabolic demands, and this has an impact on performance. Active recovery should be used by athletes between sprint repetitions with a duration-time-period of 40 to 120 s to enhance the lactate removal and possibly result in a faster restoration of muscle pH. The application of this practice at an intensity below or at the lactate threshold (i.e., exercise that will not add more lactate to the circulation) may maintain performance and in some cases, when only two sprint bouts are performed, it may help to enhance performance. When a long duration-interval-period is available between sprints (i.e., 15 to 20 min), the application of active recovery for the 1/3 of that period, while leaving some time for passive recovery, may be beneficial. Under these conditions, the faster pH restoration, increased activation and contribution of aerobic metabolism and adequate PCr resynthesis may be beneficial to performance during training and competition.

Active recovery should not be used, when a short interval (i.e., 20 to 120 s) is provided, between sprints with a duration-time-period of 4 to 15 s. This practice will increase the energy cost because of the oxygen required for exercise, thus preventing the muscle re-oxygenation leading to inadequate PCr resynthesis and decreased performance. However, during team-sport games it is not practical to advise players to stand passively after a sprint. The game demands, in many cases, require slow intensity running between sprints. Thus, active recovery between sprints should become a routine training practice. When a long duration-interval-period (i.e., more than 3 to 4 min) is available between sprints of 15 to 30 s, a very low intensity active recovery may maintain performance similar to that after passive recovery.

There is no adequate evidence to suggest that active recovery applied following a training session is beneficial in team sports. However, in individual sports and when high intensity training has been applied, it is likely that active recovery may benefit the performance outcome during the next training session. Clearly, this cannot be attributed to lactate or other currently known metabolic factors.

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In: Physical Fitness: Training, Effects and… ISBN: 978-1-61728-672-8
Editors: Mark A. Powell

Chapter 2

PROMOTING PHYSICAL FITNESS, EXERCISE TRAINING AND SPORT FOR INDIVIDUAL WITH MENTAL RETARDATION

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ABSTRACT

The aims of four investigations presented in this chapter were to assess: a) the contribution of selected factors to athletics and basketball performance; b) basketball abilities before and after a training period during one and two following sports seasons; c) the variation of sports abilities by subjects' mental retardation (MR) level. In the first and second investigations all participants performed fitness tests assessing body composition (BC), flexibility (SR), muscular strength and endurance (HG, SUP and PUP), explosive leg power (SLJ), cardiovascular endurance (ST), balance ability (FT), and motor coordination (TUGT). In the first investigation, the selected athletics performances were as follow: 60 m, 300 m, 400 m in walking, Standing long jump, Vortex throw or 100 m, Shot put, and Long jump. TUGT and body weight had contributions to 60 m, the %body fat to 300 m and to 100 m. The SLJ had contribution to Vortex throw and to Standing long jump. The PUP had contribution to Shot put. Body weight had contribution to Long jump. In the second investigation, showed that greater SLJ and PUP had positive contributions to ball handling; SLJ had positive contribution to reception and shooting. The HG and PUP had positive contributions to passing. In the third and fourth investigations, all athletes were tested through a basketball test battery (Guidetti, 2009) before and after a training period preceding the championship, during one and two following sports seasons, respectively. The purpose was to propose adapted basketball tests useful to evaluate whether individual and team ability level is adequate to participate in a specific Championship category. This test battery simplified the classification of basketball competitors with mental retardation by using functional quantitative measures. Moreover, it is also useful to follow up the training improvement in athletes with mental retardation during two consecutive sports seasons.

All our investigations showed that specific sport training could improve fitness of individuals with MR. Moreover, the possibility to determine the contribution of selected factors to sport performance should be addressed in training to help athletes to perform successfully in their competitions.

INTRODUCTION

Early in the 20th century, individuals with mental retardation were generally isolated. The last 40 years, however, have seen dramatic changes in feelings regarding people with mental retardation, resulting in a turn in public policy towards an emphasis on normalization and inclusion. As a result of these changes in developed countries, much debate and research has focused on the prevention of mental retardation, deinstitutionalization, and the education and employment of individuals with mental retardation [Horvitz, 2000]. Sport activities can be considered as a good starting point to create a new world where people with disability can improve psychological condition, social inclusion and develop movement skills and fitness. Sport can improve the quality of life, positively influencing a wide range of health conditions, both physiological and psychological [Fernhall, 1993; Dykens, 1998; Roberts, 2001; Heller, 2004]. Disabled people have, as their able-bodied peers, the same basic needs: a) the desire for acceptance and recognition; b) the need to achieve and succeed. Physical activity in the form of sports and recreation programs provide an excellent forum for the development of these values [Birrer, 2004]. Sport is a cultural phenomenon that is often viewed as a product and a reflection of society. Sport is a microcosm of the larger society; it is defined and described within the socio-cultural and socio-historical framework of the values, mores, norms and standards of a specific society or culture [De Pauw, 1995]. Moreover, it has been recognized that sport training can promote the psychophysical progress of people with mental retardation, by satisfying their primary needs and enhancing their motivation to live [Svendsen, 1982; Podgorski, 2004].

MENTAL RETARDATION: DEFINITION, CAUSES, CLASSIFICATION AND THERAPY

Mental retardation is a heterogeneous group of disorders with myriad causes. It is characterized by cognitive limitations in areas such as daily living skills, social skills, and communication [Eichstaedt, 1992; Winnick, 2000]. Mental retardation of 1950s is not what it is today, making comparisons across studies problematical, because studies are products of the time and situation [Doll-Tepper, 1990]. From 1905 to 1960, in fact, mental retardation was determined especially by Intelligence Quotient (IQ) Tests [Winnick, 2000], instead today is determined also by Adapted Behaviour Test [AAMR, 1992; Horvitz, 2000]. Adaptive behaviour is the collection of conceptual, social, and practical skills that people have learned so they can act in their everyday lives.

The current *American Association on* mental retardation (AAMR) definition of mental retardation, adopted in May 1992, states that "mental retardation refers to substantial limitations in present functioning. It is characterized by significantly sub-average intellectual functioning, existing concurrently with related limitations in two or more of the following applicable adaptive area: communication, self-care, home living, social skills, community use, self-direction, health and safety, functional academies, leisure, and work. Mental retardation manifests before age 18" [Eichstaedt, 1992; AAMR, 1992; Winnick, 2000].

Thus, three criteria must be met for an individual to be diagnosed as having mental retardation. First, *Significant sub-average intellectual functioning* refers to a person scoring below 70 to 75 on intelligence test. There are two intelligence tests used extensively throughout the world: the Stanford-Binet Intelligence Scale [Slykerman, 2005; Zhou, 2007] and the Wechsler Intelligence Scale for children-Revised (WISC-R) [D'Angiulli, 2003; Leunens, 2006] or for adults (WAIS-R) [Wechsler, 1981; Bowden, 2006; Di Nuovo, 2006]. *Existing concurrently with related limitations in two or more of the following applicable skill areas* is the second criterion. In addition to scoring below 70 to 75 on an intelligence test, significant limitations must exist in 2 or more of the 10 adaptive skill areas listed. Adaptive skills refer to the individual's ability to mature personally and socially with age. Maturity is measured according to the individual's development in each of the 10 skill areas listed. The third criterion is that mental retardation *manifests before age 18* [Begun, 2001; Winnick, 2000].

There are more than 500 disorders in which mental retardation may occur as specific manifestation. These disorders are categorized according to when they occur in the gestational period: prenatal, perinatal and postnatal (Table 1) [Winnick, 2000]. Mental retardation can be considered as final destination of different pathological processes which influence the correct functioning of Central Nervous System [DSM IV, 1995].

There are many causes of mental retardation and only one fourth of all cases can be attributed to a specific anatomical involvement of the brain where brain cells are destroyed or (as in Down syndrome) do not completely develop [Eichstaedt, 1992]. Other potential causes include fetal hypoxia or intoxication, premature birth, endocrine and nutritional disorders, postnatal disease of the brain, and sequel of some psychiatric disorders [Shephard, 1990; Begun, 2001]. Thus, the etiological factors could be classified as follow:

- Biomedical: relate to biologic processes, such as genetic disorders or nutrition;
- Social: relate to social and family interaction, such as stimulation and adult responsiveness;
- Behavioural: relate to potentially causal behaviours, such as dangerous activities or maternal substance abuse;
- Educational: relate to the availability of educational supports that promote mental development and the development of adaptive skills [Horvitz, 2000; Winnick, 2000].

Table 1. Categorization of mental retardation

Gestation Period	Mild mental retardation	Severe mental retardation
Prenatal	7-23%	25-55%
Perinatal	4-18%	10-15%
Postnatal	2-4%	7-10%

A family may suspect mental retardation if motor skills, language skills, and self-help skills do not seem to be developing in a child, or are developing at a far slower rate than the child's peers. The symptoms of mental retardation usually appear early in life. Children with the disorder tend to develop more slowly than normal. They may learn to sit up, to walk, to talk, and to perform other simple tasks later than average. Mental retardation is often accompanied by other symptoms as well. These symptoms include aggression, a tendency toward self-injury, and personality changes. Variations in normal adaptive behaviors depend on the severity of the condition.

The prevalence data are crucial to the allocation of funding and the development of services, as well as to the comparison of findings between different research efforts. The prevalence of mental retardation is affected by many factors, including the definition of mental retardation, the population studied and advances in medical technology [Horvitz, 2000]. The World Health Organization (WHO) estimates that there are approximately 170 million of people with mental retardation worldwide. In other words, nearly 3% of the world's population has some form of mental retardation. Accordingly, mental retardation is 50 times more prevalent than deafness; 28 times more prevalent than neural tube disorders like spina bifida; and 25 times more prevalent than blindness [Begun, 2001]. It is also estimated that 0.76% of the total population has known organic dysfunction that causes mental retardation [Winnick, 2000]. Mental retardation is more frequent in male than female subjects (1.5:1) [AAMR, 1992; Di Nuovo, 2002].

The classifications can not inform about individual problems and diseases. However, it may be necessary to classify individuals with mental retardation, even if it is difficult to do so accurately, and results are often disputed [Eichastedt, 1992]. A problem with classification systems is that they assign labels to people. Labels also provoke preconceived ideas about individuals' abilities, disabilities and potential [Winnick, 2000]. In 1983 Grossman listed five critical points to use when determining whether an individual is mentally retarded. These points were as follow [Eichstaedt, 1992]:

a. Recognize that a problem exist.
b. Determinate that in adaptive behaviour deficit exists.
c. Determinate measured general intellectual functioning.
d. Make decision about whether or not there is retardation of intellectual functioning.
e. Make decision about level of retardation as indicated by level of measured intellectual functioning.

There are many systems for classifying mental retardation: behavioural, etiological and educational. Until 1992, intelligence test scores was only determined by level of severity of mental retardation [Horvitz, 2000]. In1992, AAMR changed its classification from four levels based on IQ scores to two levels based on functioning levels and intensity of needed supports within the adaptive skill areas. So there are only two levels (mild and severe) classifying the degree of limitation. These levels are based on functioning in the 10 adaptive skill areas: communication, self-care, home living, social skills, community use, self-direction, health and safety, functional academies, leisure, and work [Horvitz, 2000; Winnick, 2000]. The recent mental retardation classification systems have two important world organizations as points of reference: the WHO that elaborated the International Classification of Disease (ICD) [WHO, 1992; APA, 1995] and the American Psychiatric Association (APA) that elaborated the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR) [APA, 2000; Horvitz, 2000]. The last versions of two models are, respectively, ICD-10 (1994) and DSM-IV (1996) [Di Nuovo, 2002]. Although the score criteria for mental retardation are similar between the AAMR and the DSM-IV definitions, there are important differences between the two. First, while the DSM-IV definition of mental retardation has a strict IQ cut off of 70, the 1992 AAMR definition indicates that if an individual presents with other signs of mental retardation, the IQ cut off may be raised to 75. Second, although both definitions include a sub-classification system, the bases of the two sub-classification systems differ. The AAMR definition includes a scale measuring the extent of support needed to function in the environment, focusing on an individual's strengths, support systems, capabilities and interaction with the environment. In contrast, the DSM-IV definition specifies the degrees of mental retardation severity based on the level of IQ. Further, although not formally part of the definition of mental retardation, the APA includes mental retardation in the DSM-IV, thereby classifying mental retardation as a mental disorder. The AAMR, however, explicitly states that mental retardation is neither a medical nor a mental disorder [Horvitz, 2000].

Moreover, in ICD-10 mental retardation is "a condition of uncompleted psychiatric development, characterized by compromising of intelligence abilities, as cognitive, linguistic, motor and social abilities, during the developmental age" [Di Nuovo, 2002]. Instead the DSM-IV adopts AAMR definition of mental retardation. Both models, ICD-10 and DSM-IV, explain mental retardation referring to three principal aspects: intellectual functioning, adapted behaviour and age; and underline the importance of an evaluation based on clinical evaluation, intellectual abilities, social adaptation level and psychometric tests. Both DSM-IV and ICD-10 propose test or scales to evaluate intellectual functioning and adaptive skills [Di Nuovo, 2002]. The intellectual functioning is determined by IQ scores throughout individual intelligence tests [Horvitz, 2000]. Significant subaverage intellectual functioning refers to a person scoring below 70 to 75 on an intelligence test [Winnick, 2000]. There is an assessment error of five points in IQ evaluation depending by measure instrumentation [Bogetto, 2001]. Instead it is really hard to evaluate the adaptive skill, because people behaviours can vary according to the sub-cultural group to witch they belong, to the age and drastic changes occurred in their lives [Eichstaedt, 1992; Di Nuovo, 2002]. The improvements in adaptive skills are more possible than in IQ degree, which is a steadier level [DSM-IV, 1995]. Table 2 proposes the two classifications with severity of mental retardation level and IQ level. There are some differences between two classification models. In fact ICD-10 defines the levels with fixed scores, instead DSM-IV uses greater flexibility and when there is the superimposition of scores, the severity is determined by adaptive behaviour level [Di Nuovo, 2002].

The latest classifications subdivide mental retardation in 4 levels: Mild, Moderate, Severe and Profound. Moreover, there is other level of mental retardation: no specific severity.

Mild level. The aetiology of Mild mental retardation is often a combination of unfavourable environmental conditions together with genetic, neurological, and metabolic factors. This level affects 60% of total mental retardation population. People with Mild mental retardation have to ability to listen and speak effectively and they can carry on an involved conversation. However they may have difficulty understanding some concepts and vocabulary. They haven't great problems in physical dimensions [Eichstaedt, 1992]. These have good social skills and they can become independent to live alone in community or supported setting [Bogetto, 2001].

Moderate level. People classified with Moderate mental retardation comprise up to 32% of all individuals labelled as mentally retarded. They have lower intellectual, physical and social functioning and have the tendency to be more dependent. Their limitations are more pronounced in adulthood than those of higher functioning individuals with Mild mental retardation and society seems accustomed to providing them with appropriate care, including living and vocational opportunities. People in this group are much less physically fit than people without mental retardation [Eichstaedt, 1992; DSM-IV, 1995].

Severe level. People classified with Severe mental retardation comprise up to 3-4% of all individuals labelled as mentally retarded [Bogetto, 2001]. They can understand very simple communication. They have a limited verbal skill; in fact they may use nonverbal techniques (e.g., gestures, sign language). People in this group have typically significant motor and health problems. Their social interaction can be limited. They need certain amount of assistance with daily activities but can acquire requisite self-help skills [Eichstaedt, 1992; DSM-IV, 1995]. They can make social and economic adaptation in sheltered workshop or in a routine job under supervision [Eichstaedt, 1992; Bogetto, 2001].

Profound level. People with Profound mental retardation comprise up 1-2% of total population with mental retardation. This group often presents a neurological diagnosis which explains this condition [Bogetto, 2001]. Communication skills are very limited, in fact often it is throughout nonverbal sounds. They have few useful motor skills and may be medically fragile. Their social adjustment may be nonexistent. They are totally dependent and they need training in self-care skills (feeding, dressing and toileting) [Eichstaedt, 1992].

No Specific Severity of mental retardation. The diagnosis of No Specific Severity of mental retardation can be used when psychiatrists can suppose a mental retardation but the subjects can't evaluated by standardized IQ tests [Horvitz, 2000; Di Nuovo, 2002].

Individuals with mental retardation present a diversity of abilities and potential, and the educator must be prepared to accept this diversity [Winnick, 2000]. Therapeutic recreation is a subset of the broad field of recreation; its focus is to provide services to individuals with disabilities. Austin and Crawford (1991) define "Therapeutic Recreation" as the purposeful nature of the use of recreation/leisure as an intervention, and the personal enhancement of the client as a result of the intervention. That is, recreational activities, including motor skill and physical fitness development, can be instrumental in the therapeutic recreation leader's pan to improve subjects' cognitive, emotional and social abilities [Eichstaedt, 1992]. Individuals with mental retardation may have difficulties understanding the effects of behaviour on health, the risks and benefits of medical treatment, and the process of accessing appropriate and necessary health services [Horvitz, 2000] Thus, the therapists and teachers become fundamental for people with mental retardation. Therapy programs should be specific to each subject, and the outcomes should allow individuals to progress upward on the developmental scale. All therapists use an approach, which concerns for the emotional, social, intellectual, and physical well-being of their subjects. All therapists can provide a dynamic combination that allows cooperative planning and service delivery [Eichstaedt, 1992]. The project of rehabilitation should have specific goals and instruments to allow the success and gratification of people with mental retardation [Zanobini, 1995].

First goal to achieve for people with mental retardation is autonomy. Autonomy is understood as the ability to direct one's behaviour responsibly, to make choices while taking into account one's own and others' needs, and to develop social relations based on reciprocity. Two main areas exist in which the concept of autonomy operates: "internal" autonomy, which manifests itself first in the individual's awareness (thinking, feelings) and then in actions (spontaneous or intentional) and also "external", which basically means the consent of the environment to the realisation of an individual's own autonomy [Dluzewska-Martiniec, 2002]. Individual rehabilitation project must no cancel the pathology but decreases deficit, considering the needs and history of individual [Zanobini, 1995]. The development of autonomy goes through certain phases: from complete dependence, through independence, to co-dependence. The best conditions in which it can be realised are emotionally safe conditions. The psychological autonomy of an adult individual is characterised by the feelings of freedom, independence, determining one's goals, free choice, and self-determination within the framework of the norm. In other words, the person is able to function in a subjective way [Dluzewska-Martiniec, 2002].

Table 2. Comparisons between ICD-10 and DSM-IV in relation to mental retardation level and IQ score

ICD-10		DSM-IV	
Level	IQ score	Level	IQ score
Mild	50-69	Mild	50/55-70
Moderate	35-49	Moderate	25/40-50/55
Severe	20-34	Severe	20/25-35/40
Profound	< 20	Profound	< 20/25
No Specific		No Specific	

There are few opportunities for them to act independently, because they become passive, dependent, externally directed, and function in an instrumental way. It could be due by two factors: a) a low level of competence characterising these individuals; b) the influence of the social environment providing the individual with information concerning his or her abilities [Dluzewska-Martiniec, 2002]. Thus, program development must begin with the individual and an individualized education program (IEP) is an important departure point in the development of effective program instruction [Eichstaedt, 1992; Frey, 2008]. An IEP is a written document that essentially describes the student's current level of education achievement, identifies goals and objectives for the near future, and lists the educational services to be provided to meet those goals. The IEP should include [Eichstaedt, 1992]:

a. the individual's present level of performance;
b. annual goals;
c. short-term behavioural objectives;
d. projected dates for initiating services and the anticipated duration for achieving these goals;
e. strategies and materials for achieving these goals;
f. the specific educational and related services provided the athlete; and
g. the extent to which the subject will participate in regular education.

HEALTH-RELATED PHYSICAL FITNESS, EXERCISE TRAINING AND SPORT ACTIVITIES

Determinants that define health-related physical fitness are body composition, cardiovascular endurance, flexibility, motor coordination, muscular strength and endurance [Eichstaedt, 1992; Kittredge, 1994; Chanias, 1998; Graham, 2000]. Many studies reported that individuals with mental retardation demonstrated poor levels on fitness and on related standard tests [Rimmer, 1992; Chanias, 1998; Graham, 2000; Van de Vliet, 2006; Lahatinen, 2007; Carmeli, 2008; Frey, 2008]. There is evidence that some differentiation in performance is based on the cause of mental retardation [Beunen, 1988]. Beadle-Brown et al. [Beadle-Brown, 2000] showed that individual with the highest intelligent quotient showed the greatest increases in skills over the time. However, this low levels on fitness tests could be attributed to five potential factors: a) sedentary life and fewer opportunities for participation in structured physical activity programs; b) physical characteristics such as short stature; c) lack of coordination and efficiency; d) infrequent opportunities to practice test items; and e) lack of motivation during testing and tendency to stop when uncomfortable [Graham, 2000]. All these factors suggest that people with mental retardation are in considerable health risk [Chanias, 1998; Rimmer, 2004]. Therefore, regular physical fitness activity and sport participation throughout life are encouraged as being important for preventing diseases, decreasing health risks, promoting an active lifestyle, physical and emotional well-being, and finally increasing work capacity, which may further decrease the need for premature institutionalization [Rimmer, 1992; Fernhall, 1993; Chanias, 1998; Shapiro, 1998; Carmeli, 2005; Fragala-Pinkham, 2005; Van de Vliet, 2006; Frey, 2008]. There is a general perception that the prevalence of overweight status/obesity is greater among populations with mental retardation compared with populations without disability. Inactivity and inappropriate eating habits may be a major cause of the high obesity rates of individuals with mental retardation [Fernhall, 1993; Podgorski, 2004]. Therefore, people with mental retardation generally demonstrate improved health-related physical fitness parameters when exposed to structured exercise regimes [Chanias, 1998]. Many facets such as work, maintaining a household, cooking, self-care, and recreation require the individual to possess a certain degree of physical stamina. People with mental retardation need an adequate amount of fitness to contribute to work-related tasks and enjoy and to benefit from participation in recreational and leisure activities [Graham, 2000]. Unfortunately, several barriers, as segregated environments, have been noted to inhibit successful promotion of skill development and programming [Whorton, 1994). For these reasons, several studies recommend that professionals begin to target population with mental retardation in various health promotion initiatives, including higher participation in physical and sport activities [Rimmer, 2004].

The benefits of physical fitness activities are well documented in the literature and they are no different for persons with mental retardation than for the general population. Health, social, personal benefits and autonomy can be derived from physical fitness practices [Eichstaedt, 1992; Dluzewska-Martinyec, 2002; Podgorski, 2004].

Adapted physical activity is about physical activity spanning both the individual's lifetime and the multitude of special population behaviours [Doll-Tepper, 1990]. Adapted physical education is an individualized program of physical and motor fitness; fundamental motor skills and patterns; and skills in aquatics, dance, and individual and group games and sports designed to meet the unique needs individuals [Eichstaedt, 1992; Winnick, 2000]. Adapted physical activity should be appropriate to the age, social development within the peer group, and cultural environment in which they exist [Doll-Tepper, 1990]. Although an adapted physical education program is individualized, it can be implemented in a group setting and should be geared to each athlete's needs, limitations and abilities. Adapted physical education should emphasize an active program of physical activity rather than a sedentary alternative program [Winnick, 2000; Fragala-Pinkham, 2005]. Most people with mental retardation, in fact, have an abundance of free time. It is important to teach them to use this time safely, constructively and enjoyably rather than sitting idly in front of television set [Eichstaedt, 1992]. For this motivation an adapted physical activity can be useful to improve the life of people with mental retardation.

Adapted sport refers to sport modified or created to meet the unique needs of individuals with disabilities. Adapted sport may be conducted in integrated with non-disabled athletes or in segregated environments that include only these persons with disabilities. Adapted sport activity may also be conducted for leisure or recreational purposes within formal, open or unstructured programs or as a part of the lifestyle of individuals and groups. Adapted sport activity may also be conducted for wellness, medical or therapeutic reasons. It is important that purposes are developmentally appropriate [Winnick, 2000].

Like other members of society, some individuals with mental retardation participate in sport for purely recreational reasons, to develop skills and fitness and to have fun socializing with other people. For others, the transition from recreational sport to intensive training and competition is a natural progression for testing personal limits and pursuing athletic dreams and goals [Van de Vliet, 2006]. Sport can improve quality of life for these people. The main dimensions of quality of life include: (a) emotional well-being, (b) interpersonal relations, (c) material well being, (d) personal development, (e) physical well-being, (f) self-determination, (g) social inclusion, and (h) rights [Wehmeyer, 1998]. Like individuals in the general population, individuals with mental retardation are unlikely to participate in physical activities; either because they lack the motivation or the opportunity to be involved in fitness programs.

Sport could be considered important in the lives of people with mental retardation, because it is the product of physical and cognitive potentials. The physical potential includes physical fitness and skill proficiency. The cognitive potential includes intelligence as a multidimensional construct including reasoning, planning, decision making processes, learning quickly, and learning from experience [Van de Vliet, 2006].

Track and field, for example, has become one of the most popular individual sports for people with mental retardation, both for recreational reasons and for motor skills and fitness development [Van de Vliet, 2006]. Track and field for athletes with mental retardation includes all fundamental movements such as walking, running, jumping, and throwing [Eichstaedt, 1992]. How to improve athletics performance is primary concern for coaches and researches in International Paralympics Committee (IPC). Athletes' performances may be represented by the official results in a specific championship. Moreover, to help athletes perform successfully in their competitions, important factors related to a successful performance should be identified. The relationship between sport performance and fundamental factors was studied in various sports, for example in wheelchair basketball [Wang, 2005], basketball and volleyball for athletes without disability [Jette, 1976; Frey, 2008; Forthomme, 2005] but it has not been investigated in track and field for athletes with mental retardation. Therefore, we were interested in assessing the contribution of selected factors to the athletics performance in adults with mental retardation [Franciosi, 2009a]. Twenty-nine trained athletes with mental retardation (32.8 yr ± 6.1) participated in this study. The selected fundamental factors included anthropometric measurements, flexibility, muscular strength and endurance, explosive leg power, cardiovascular endurance and motor coordination. The athletics performances were 60 m, 300 m, 400 m in walking, Standing long jump, and Vortex throw for athletes with less physical abilities that participated in no agonistic competitions, or 100 m run, Shot put, and Long jump for athletes with good physical abilities that participated in agonistic competitions. Our results revealed the possibility to determine the contributions of selected factors to the athletics performance. In fact, motor coordination and body weight had significant contributions to 60 m (99%, $p<0.01$) and the %body fat had significant contribution to 300 m and 100 m (76%, 50%, $p<0.05$, respectively). The explosive leg power had significant contribution to Vortex throw and Standing long jump (28%, $p<0.05$). The upper-body strength and muscular endurance had significant contribution in Shot put (83%, $p<0.05$). The body weight had significant contribution in Long jump (99%, $p<0.05$). These results should be addressed in athletics training to help athletes with mental retardation to perform successfully in their competitions.

Team sports, as basketball, are a popular way for individuals with mental retardation to become involved in physical activity. Basketball is a popular activity in physical and sports education program for people with mental retardation, because it incorporates both motor skills such as running, jumping, shooting and social aspects [Baldari, 2009; Guidetti, 2009]. In fact, problems of interpersonal interaction are common in adults with mental retardation [Kellett, 2005; Guidetti, 2009], therefore the practice of adapted basketball training might have improved their interpersonal relationships. This is in close relationship with the nature of the basketball performance in which person-environment interaction, high decision-making processes, and comprehension of game situations are very important [Wang, 2005]. Similarly to the investigation about the identification of fundamental factors in track and field performance, we conducted a study to determine the contributions of selected fundamental factors to basketball performance in adult players with mental retardation [Franciosi, 2009b]. Fourteen male trained players with mental retardation (32.1 yr ± 7.4) participated in this study. The athletes' performances were assessed using adapted basketball tests that assessed 4 ability levels of increasing difficulty (from I to IV), each one characterized by the analysis of 4 fundamental areas: ball handling, reception, passing and shooting [Guidetti, 2009]. The fundamental factors included anthropometric measurements (height, weight and BMI), static balance, muscular strength and endurance, explosive leg power, cardiovascular endurance and motor coordination. This study showed that greater explosive leg power and upper-body muscular strength and endurance had significant contributions to ball handling (85%, $p<0.01$); and explosive leg power had significant positive contribution in reception (59%, $p<0.05$) and shooting (64%, $p=0.01$). The forearm muscular strength and upper-body muscular strength and endurance had significant contributions to passing (78%, $p=0.01$). Moreover, the greater explosive leg power had significant contribution in level II (46%, $p<0.05$), in level III (52%, $p<0.05$), and in global score (60%, $p<0.05$). These results showed the possibility to determine the contribution of selected fundamental factors to basketball performance. Therefore, the basketball coach could improve a selected fundamental factor to increase specific basketball ability.

Another aspect to consider in athletes' training is physical fitness testing. In the past, physical fitness testing and training was based primarily on motor performance in such skills such as agility, balance, coordination, power speed, and reaction time. Today experts agree that physical fitness should empathise the relationship between health and physical activity rather than motor fitness [Eichstaedt, 1992]. It has been recognized that training can promote the psychophysical progress of people with mental retardation , by satisfying their primary needs and enhancing their motivation to live [Svendsen, 1982;

Podgorski, 2004]. The training is a repetition of loads to achieve a result with structural, biomechanical and functional changes [Orsatti, 1995]. Successful implementation of an achievement-based training program depends on: a) a very careful selection of physical activities appropriate to the ability levels of each individual, b) adaptation in learning and performing in environment to simplify the movement task, c) choice of appropriate teaching methods that are structured and tailored to suit the individual needs [Doll-Tepper, 1990; Eichstaedt, 1992]. The coach must: a) define the specific behaviour to be developed or changed; b) determine a present level of performance; c) establish one or more goals; and d) implement a behavioural intervention program [Winnick, 2000]. The first criterion is that the performer should be successful and gain fun and enjoyment from the activity [Doll-Tepperk, 1990]. The foremost consideration in any fitness program must be safety and well-being of each participant [Eichstaedt, 1992]. Different factors may explain why training can affect the motor skills of adults with mental retardation. The exposure to a complex environment, such as motor skill training, can affect neuronal and non-neuronal plasticity by increasing cell proliferation, cell survival, and net neurogenesis in particular regions (e.g., motor cortex and cerebellum) of normal brain [Dong, 2004]. In addition, whereas motor skill learning can increase the number of synapses, the exercise can increase capillary density in response to increased oxygen demand [Dong, 2004]. However, there is still a gap in the knowledge about the intermediary cellular and molecular events that link changes in skills to changes in neuronal, non-neuronal cells, or vascular structure and function. The positive effects induced in the normal brain by training could be speculated also for people with mental retardation and could explain their improvement in ability.

Physical fitness components are assessed in different ways. Although most tests have good basic validity in general population, this has not necessarily been shown in individuals with mental retardation. However, it is imperative to use test that are validate for use in population with mental retardation [Van de Vliet, 2006]. Many studies indicate that there is a need to find appropriate, valid and reliable testing procedures for persons with mental retardation [Kittredge, 1994]. Testing is defined as a technique to collect data using specific tools and procedures, such as systematic observation. Assessment involves interpretation of test results. Using test scores, the coach can begin to determinate which athlete is the best dibbler, shooter, passer, or rebounded [Eichaestadt, 1992]. The testing can be standardized test, which involves the formal evaluation of a movement response to a standard set of test item, or informal test, which responses according to the environment [Eichaestadt, 1992; Winnick, 2000]. It is important for the professional to determinate whether the test environment is adequate for the movement needs of the person to be tested. Before testing, the physical coach must review the test manual to determinate specific equipment needs and the design of equipment, stations, and markings [Eichaestadt, 1992]. Persons with mental retardation could present unique testing problems, as follow: a) the limited mental ability and short attention span, could cause difficulties in understanding, following complicated test directions; b) they are not fully motivated or not motivated enough to try their best; and c) test ideal for general population are often used indiscriminately with this special population [Eichaestadt, 1992]. Although today athletes with mental retardation have achieved an important role in many sports, the modern sports literature is still poor in relation to the ability evaluation tests in sports for athletes with mental retardation. Referring to the importance of some sports, such as basketball, to improve physical efficiency and to improve psycho-social well-being of athletes, we focused our attention to identify an appropriate test modality to assess basketball ability of athletes with mental retardation [Guidetti, 2009]. The aim of this study was to allow the competitions participation of athletes, referring to their technical potentialities and so to allow the respect of the adapted rules of the game. Therefore, 15 trained basketball players with mental retardation (30.3 ± 7.9 yr) were involved in our study. Athletes were tested before and after 4-month training preceding the championship. The tests assessed 4 levels of ability, each one characterised by 4 fundamental areas of this game: ball handling, reception, passing and shooting. Each area was divided into 5 specific components. The administered tests revealed useful to create a functional evaluation system for basketball athletes with mental retardation. Similarly to the functional classification system and the field-testing for wheelchair basketball athletes [Vanlandewijck, 2004], the basketball test battery proposed in this study could be useful to evaluate whether individual and team ability level is adequate to participate in a specific Championship category. In fact it simplifies the classification of basketball competitors with mental retardation by using functional quantitative measures. It could also be useful to follow up any training improvement in athletes with mental retardation.

Although several studies showed the positive effects of exercise and physical activity on health and well-being for individuals with mental retardation [Van de Vliet, 2006; Frey, 2008], there is a paucity of information about the influence of sport training on specific sport abilities. Therefore, we concluded our studies with an investigation designed to assess basketball abilities before and after a 6-month training preceding the Italian Basketball

Championship for players with mental retardation across 2 sports seasons and to analyze the variation of specific basketball abilities by subjects' mental retardation levels [Baldari, 2009]. The aims of this study were to assess basketball ability before (PRE) and after (POST) a 6-month training in athletes with mental retardation across 2 sports seasons (ss) and to analyze the variation of basketball abilities by subjects' mental retardation level. Fifteen trained basketball players with mental retardation participated (30.4 ± 7.7; mental retardation levels: 3 Mild, 8 Moderate, 3 Severe, and 1 Profound). Athletes were tested before and after a 6-month training during 2 following sports seasons (ss1 and ss2). The tests assessed 4 ability levels, each one characterized by the analysis of 4 fundamental areas (ball handling, reception, passing, and shooting), divided into 5 specific components. The athletes' global score improved after training in both ss1 (41.5 ± 12.0 vs. 48.6 ± 15.4; $p<0.01$) and ss2 (41.7 ± 12.4 vs. 50.8 ± 16.2; $p<0.01$). Levels II, III, and IV showed an increase both after each sports seasons and the 2 following sports seasons ($p<0.01$). No significant difference was found between POST-ss1 and POST-ss2 due to score decrease during the resting period between the 2 sports seasons. In both sports seasons, global and level scores were negatively correlated to mental retardation level indicating that athletes with a lower mental retardation obtained higher ability scores. Our results showed that a 6-month training caused a general improvement, especially evident in levels II and III in both sports seasons. Global and level scores were negatively correlated to mental retardation level ($p<0.05$) indicating that athletes with a lower mental retardation obtained higher scores.

CONCLUSION

Regular physical activity and exercise could improve athletes' health and well-being [Fernhall, 1993; Dykens, 1998; Heller, 2004; Horvitz, 2000; Fragala-Pinkham, 2005], and the sport through a standard training and competition could be useful for testing personal limits and pursuing athletic dreams and goals [Van De Vliet, 2006]. Our studies demonstrated that a specific basketball-training program produced a general improvement in athletic performance and in tested basketball abilities for all athletes. Similarly to the functional classification system and the field testing for wheelchair basketball athletes [Vanlandewijck, 2004], the basketball test battery proposed in these studies could simplify the classification of basketball competitors with mental retardation by using functional quantitative measures [Guidetti, 2009]. Athletes' classification could allow their inclusion in an appropriate basketball category. Moreover, the basketball test battery could be useful for improving and monitoring training.

Furthermore, our findings presented in this chapter suggest the possibility to assess the contribution of selected fundamental factors to basketball and track and field performances. This should be addressed by coaches in training to help adult athletes with mental retardation to perform successfully in their competitions. The observations of these studies pertaining to the frontline athletes could provide useful guidelines for training to optimize sport performance.

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In: Physical Fitness: Training, Effects and… ISBN: 978-1-61728-672-8
Editors: Mark A. Powell

Chapter 3

LOW COST PHYSICAL FITNESS PROGRAMS ACROSS THE LIFESPAN OF INDIVIDUALS WITH INTELLECTUAL AND DEVELOPMENTAL DISABILITY: IMPROVING CARDIO-VASCULAR FITNESS, FUNCTIONAL ABILITY AND MUSCLE STRENGTH AND REDUCING INFIRMARY VISITATION

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ABSTRACT

Background

Individuals with intellectual and developmental disability (IDD) too frequently maintain a sedentary life style, resulting in health harming consequences and early aging. Physical intervention programs have been suggested and implemented with this population in the past, mostly with success, but with extreme costs.

The Interventions

The present chapter describes three low cost intervention programs for children and adults at different functional levels and intellectual ability. All programs have been implemented by volunteers trained and supervised by an experienced physical therapist.

Project 1 – 15 children (Mean age: 7.9) diagnosed at a moderate-severe cognitive level, were trained daily on a treadmill for the duration of two month with significant improvements in aerobic capacity and functional ability.

Project 2 – 17 ambulating adults (mean age: 42) diagnosed with moderate cognitive level, were trained twice weekly on a treadmill, for the duration of one year. Results were compared with a control group (n=17) matched for function, gender, age, and primary diagnosis and showed significant reduction in pulse at rest ($p<0.05$) and during exercise ($p<0.001$) only for the trained participants. A significant reduction was also observed in infirmary visitation ($P<0.025$) for the research group alone.

Project 3 – 4 adults (mean age: 47.5) constant wheel chair users who have never walked, diagnosed with moderate cognitive level, were trained twice weekly on a four wheeled walker, for the duration of two month. Results were compared with a control participant (n=1) and showed significant reduction in pulse at rest ($p<0.05$) and during exercise ($p<0.001$) in muscle strength ($p<0.001$) and functional ability ($p<0.01$).

Conclusions

The results of all three projects indicate that a low cost exercise program can yield extremely positive results in many areas that influence clients' health. The author suggests implementing such programs for individuals with IDD on a regular basis since childhood and across their lifespan. Further research is needed to examine the long term effect of such intervention programs on longevity, morbidity and mortality.

INTRODUCTION

Individuals with Intellectual and Developmental Disability (IDD) have been found by many researchers to lack in physical fitness, when compared to peers without IDD[1-8]. Measures of poor fitness performance where demonstrated in cardiovascular fitness [9-12], body composition [12-14], muscular strength, endurance [12, 15,16] and flexibility [12]. Many reasons have been suggested for this poor disposition:

1. Passive life style [4, 11, 17],
2. Low motivation [18],
3. Psychological or physiological barriers or motor passivity [8],
4. Physical characteristics such as short stature [12, 19]
5. Lack of coordination and efficiency [20], and
6. Lack of motivation during testing and a tendency to stop when uncomfortable [12, 21].

Of all the factors examined, it was found that inactive\sedentary life style was the most harmful to physical fitness [4, 17, 22, 23]. Sedentary life style is associated with high risk of developing Obesity, Coronary arterial diseases, heart attacks [24]. Moreover it was established that the lack of physical fitness of individuals with multi-disability can lead to early aging phenomena and states of illness compared with the population with no disorders [25]. The above mention assumption was proven by a longitudinal national study held in Sweden. The study analyzed the long-term effect of leisure-time physical activity on incident cases of coronary heart disease (CHD) among women and men through a national sample of 2,551 women and 2,645 men, aged 35–74. The results of the investigation suggest that physical activity has positive long-term effect of on CHD risk among women and men [26].

It appears that adults with an IDD may be particularly at risk for declining health associated with aging and low physical fitness. Due to these alarming data it is clear that intensive habilitative effort must be introduced to reduce complications and decrease the consequences accompanying old age in this population[27].

Exercise Programs for Ambulatory Individuals with IDD

Findings show that regular exercise can improve the functional status and can decrease the level of assistance that people with disabilities may need to perform activities of daily living by increasing muscular strength and endurance, flexibility, balance, and cardio- vascular and respiratory efficiency [28]. Exercise can also reduce the incidence of secondary conditions in persons with disabilities (loss of cardio-respiratory and muscular function, metabolic alterations, and systemic dysfunctions), which may maintain or enhance quality of life [29].

The positive contributions that exercise programs entail have led to the implication of various intervention programs for individuals with IDD.

These programs included:

1. Stair climbing [30];
2. Walking, running, stretching & aerobic exercises [17];
3. Floor and flexibility exercises [5];
4. A mile run, use of a rowing machine, weight lifting, training bicycle [30, 31];
5. Treadmill training [4, 33, 34];
6. Walking [35].

These programs have all report gained improvements such as: Muscular endurance [17], Physical fitness and reduction of pulse per minute [30], muscle strength [4, 36] functional skills [33] and an improved health perception as deduced from reduced visitations to the infirmary [34]. Nevertheless most of the intervention programs have been planned for ambulatory individuals and have been carried out on research budgets and were too closely supervised, hence unrealistic to real life possibilities of individuals with IDD [4].

Exercise Programs for Non-Ambulatory Disabled Individuals with IDD

Due to the apparent urgent need in exercise programs for individuals with IDD the question arise as to specific intervention program that will be appropriate for adults with IDD that are non ambulatory, and are constant wheelchair users. This population has to overcome extreme barriers preventing them from participating in most training programs. Such population might be perceived as candidates for maintenance programs only.

On the other hand, due to the fact that this population have different levels of muscle control and coordination, building muscle strength and improving coordination by exercising may be especially beneficial. Additionally, cardiac and pulmonary diseases are the primary and secondary causes of death among this population [37]. Thus, an exercise program to improve the cardiopulmonary function is of great importance.

Health promotion and prevention strategies in the area of exercise and fitness may delay the onset of these health concerns or may ameliorate them before they become problematic.

Existing Programs for Severely Disabled Individuals with IDD

Paraplegic patients are accustomed to walking exercises as part of their daily routine. On the other hand mobility for severe handicapped individuals is less common [38]. Despite the rarity of such programs some have been implemented in the past.

Therapeutic walking for 10 children with C.P., for a period of three month, three times per week, each session lasting for 25 minutes have resulted in improvements in walking, standing as well as improvements in transfers in some of the participants [38]. Muscle strengthening program have improved muscle strength and ambulation in a group of 14 children with C.P. training three times a week, for six weeks [40]. Similar short term intervention programs, all implemented with ambulatory children with C.P. have yielded improvements in muscle strength, and walking speed [41] and were even found to improve sense of well-being [42]. In only one article such programs were administered for ambulating adults and produced similar results to those found for children [43].

Summary of Introduction

The evidence suggests that individuals with IDD, especially non-ambulatory severely handicapped individuals, tend to leave a sedentary life style, thereby becoming a population at risk for secondary medical complications on top of their primary disability. Such complications might be the cause of early signs of aging typical for this population. Most physical intervention programs, to date, where addressing ambulatory pediatric participants and were costly. The present chapter describes three low cost intervention programs, which were implemented with participants at different functional levels, different ages and moderate to severe level of cognitive level.

Methods

Project 1 [44]

Goal: To evaluate the influence of a physical intervention program on functional ability and physical fitness of children with IDD.

Participants: The research population consisted of 15 children (7 girls and 8 boys) ages 5–10 years (mean: 7.9), attending a daily educational facility. All the children presented motor abilities equivalent to that of 7 to 15-month-old infants without disabilities and low muscle tone. Of the group, 4 children had moderate IDD levels, 8 severe, and 3 profound.

Equipment: A 1400 trimline model treadmill by Hebb U.S.A. A Beat 3 pulse measurer by Polar

Intervention program: a daily low graded treadmill program each session lasting 20–30 min, for the duration of 2 months.

Trainers: A young woman performing her national service duty with no prior experience in children with IDD or with physical intervention programs. She was introduced and trained in regards to the population and the intervention program for one month and was supervised on a daily basis by a trained physical therapist (ML) throughout the intervention program.

Measurements: The large number of interfering factors did not enable compatibility among a similar comparison population. Thus, using the group as its own control enabled to neutralize interfering factors, such as age, diagnosis, functional level, behavior problems, as well as quantity, type, and quality of other paramedical treatments. Heart rate at rest and during exercise, and functional ability were measured on three occasions; 2 months pre intervention initiation (O_1), at the beginning of the intervention (O_2) and two month after O_2 - post intervention(O_3). Functional ability was measured using a tool that was constructed especially for the present intervention, due to lack of an appropriate tool to measure quick changes in functional ability of cognitively impaired children during a short-term intervention. The tool used increments holding face validity such as time (minutes) and distance (meters). The tool has been constructed by an experienced physical therapist working with this population for 10 years (M.L.) and supervised and corrected prior to its use by three experienced physical therapists not connected with the intervention, thus giving the tool content validity. The tool was found to show Inter-rater reliability of ICC (2;1) = 0.95 and 0.8 reproducibility value (when measured between O_1-O_2 measurements).

General data: On average the participants exercised 37.7 days for 19.9 minutes per day. The average initial speed was 1.7 kph and the end average speed 2.7 kph. The average initial duration of each exercise session was 6.7 minutes and 28.8 minutes at the end of the intervention. The average initial energetic expenditure per session was 223 kcal (kilo calories) and the average energetic expenditure in the final session was 1,965 kcal per participant.

Project 2

Goal: To evaluate the influence of a physical intervention program on infirmary visitations and physical fitness of adults with IDD.

Participants: 17 individuals with moderate level of cognitive impairment, 6 women and 11 men, aged 21-65 (Mean = 42.3± 12) living in residential centers in Jerusalem, Israel. (They were authorized to participate by the facility's physician after undergoing an E.K.G. test). Participants were matched with a control group (n=17) on the basis of cognitive level, functional ability, age, sex, and primary diagnosis (Table 1).

Equipment: A 1400 trimline model treadmill by Hebb U.S.A.
A Beat 3 pulse measurer by Polar

Intervention program: One year, two- three weekly basis, low graded treadmill training.

Trainers: Volunteers with no prior experience in individuals with cognitive impairment or with physical intervention programs. They were introduced to the population and trained to perform the intervention program for one month and were supervised on a weekly basis by a trained physical therapist (ML) throughout the intervention program.

Measurements: Pulse during exercise (highest pulse during five minute walking – individually adjusted speed and duration); Pulse at rest (lowest pulse during five minute sitting); Yearly visitations to the infirmary (as reported on infirmary medical records).

Table 1. Project 1: demographic data of participants

Variable	Research group	Comparison group
Mean age	42.7	42.2
Age range	21-65	29-66
Women	6	6
Men	11	11
Level of IDD	Moderate	Moderate
Main diagnosis:		
Blindness	1	1
Down syndrome	2	2
Edematic legs	2	2
Cerebral Palsy	4	1
Idiopathic IDD	8	11
Total N of participants	17	17
Annual visitation to infirmary	213	207
Mean monthly visitation to infirmary	17.8	17.3

General data: Mean exercise duration increased from 3.6 minutes at initiation to 16 minutes at the end of one year. Mean speed increased from 1.6 $_{K/H}$ at initiation to 3.5 $_{K/H}$ at the end of one year. Treadmill inclination increased for all participants from 0^o at program initiation to 7.5^o at the end of one year. Mean distance increased from 180m. at initiation to 900m. at the end of one year.

Project 3

Participants

Goal – To examine the influence of a physical activity program for adults with IDD and C.P. who have never walked, on muscle strength, ambulation and physical fitness.

Participants - Four adults, with diagnosis of C.P. (Two with severe diplegia and two with quadriplegia) who have never walked participated as the research group. Participants where at the age range of 36-61 mean age 47.5.

A fifth adult with quadriplegia, which has never walked, at age 58, participated as comparison. This resident was originally planned to be a part of the group, but due to technical reasons could not participate in the activity plan and was only measured with pre-post measurements.

All participants displayed a moderate level of IDD, and all dwelled in a residential setting, and were treated by the same caregivers.

Equipment - A four wheeled walker with full pelvic and trunk support manufactured by the Rifton Company (Figure 1).

A polar pulse transmitter, type beat 3 was used to constantly monitor and measure heart beat during and at the end of each training session.

A stop watch was used to measure task performance.

Intervention program – Every participant used the 4 wheeled walker, 3-4 times per week, for half an hour sessions, for the duration of one month.

Trainers: Volunteers with no prior experience in individuals with cognitive impairment or with physical intervention programs. They were introduced to the population and trained to perform the intervention program for one month and were supervised on a weekly basis by a trained physical therapist throughout the intervention program.

Measurements – The following measurements where all measured at the beginning and at the end of the intervention program. They were all taken by the physical therapist supervising the intervention (ML).

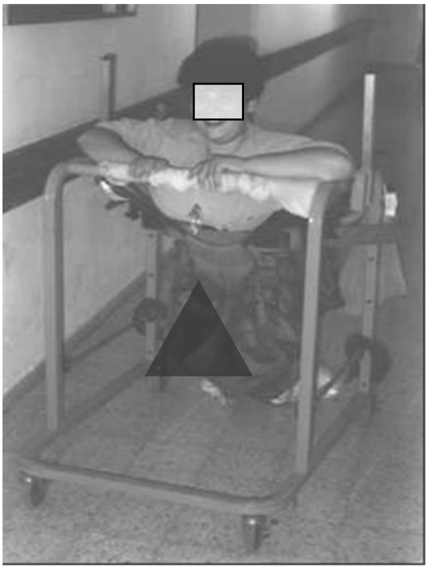

Figure 1. A participant on a four wheeled walker with full pelvic and trunk support

- Pulse at rest – Pulse at rest can be correlated to aerobic fitness and can be used as a rough measure for this parameter. All measurements were made by using the polar heart beat transmitter. Heart rate at rest was measured while participants set in their wheelchairs. The result reported is the lowest reading during a 5 minute measurement.
- Pulse recovery at end of training session – measurements were made by using the polar heart beat transmitter. Pulse recovery was measured immediately at the end of the activity and there after continuously measured for three minutes. Reported results are the heart rate at the end of each consecutive minute.
- Muscle strength – The Glutius Maximus (GM) muscle was selected to represent a change in muscle strength. It was selected due to the fact that it was the most active muscle during the above mentioned intervention program. Muscle strength was measured according to Manual muscle testing protocol [45].
- Task performance – Every participant was measured while performing a walk through a 20 meter corridor. All participant underwent an introduction trial prior to measurement taking. The instruction given to all participants at measurement taking was "get to the pole at the end of this corridor as fast as you can". No physical assistance was given during measurement but vocal encouragement was used when participants discontinued walking. Each Task was performed and measured for each participant twice at beginning of the program and twice at the end of the program. The reported results are the mean of two trials at each measurement.

RESULTS

Project 1

All measurements where calculated using a two-tailed, paired T-tests performed on an SPSS program 14.1.

A significant reduction (two-tailed, df=14, **p<0.001**) in pulse was observed between the second (O_2) and third examinations (O_3); the period of therapeutic intervention. While no change in pulse at rest was found between the first (O_1) and the second (O_2) examination. The average decrease in pulse at rest per child for this short period of two month was 11.5 (Figure 2).

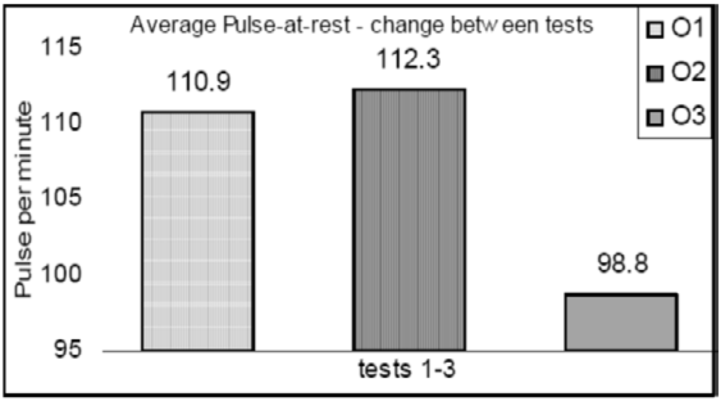

Figure 2. Change in average pulse at rest across tests

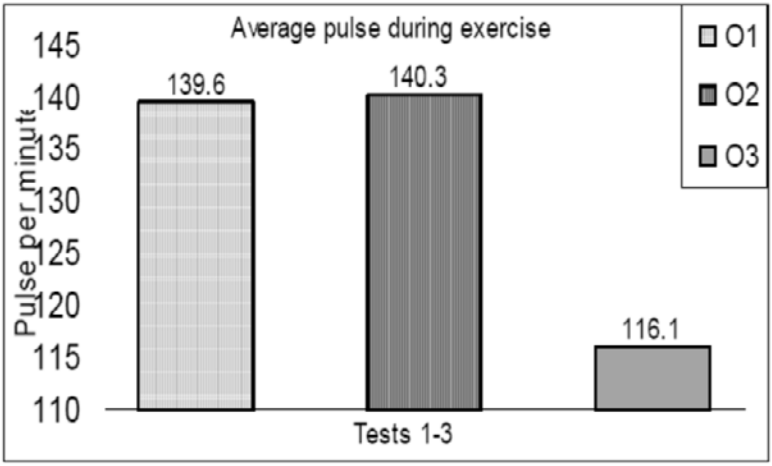

Figure 3. Change in average pulse during training

A significant (two-tailed, df=14**, p<0.000**) reduction was found in pulse during training between the second (O_2) and third tests (O_3); the period of therapeutic intervention, while no change in heart during activity was noticed between O_1-O_2. The average change in the pulse during activity within those two month of intervention was -24.13 per child. (Figure 3).

A significant improvement in functional ability (two-tailed, df=14, p<**0.038**) was found between (O_2-O_3); the period of therapeutic intervention, while no change in functional ability was noticed between O_1-O_2 (Figure 4).

A significant negative correlation (r=**-0.44**) was found between the change in heart rate at rest (Correlative to aerobic fitness level) and improvement in functional ability, suggesting a connection between improved physical fitness and elevated functional abilities for the research population (Figure 5).

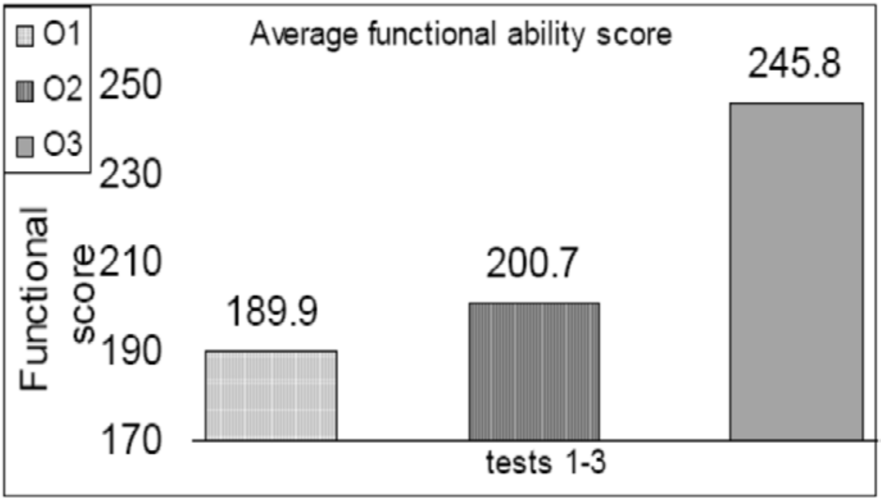

Figure 4. Average change in functional scores

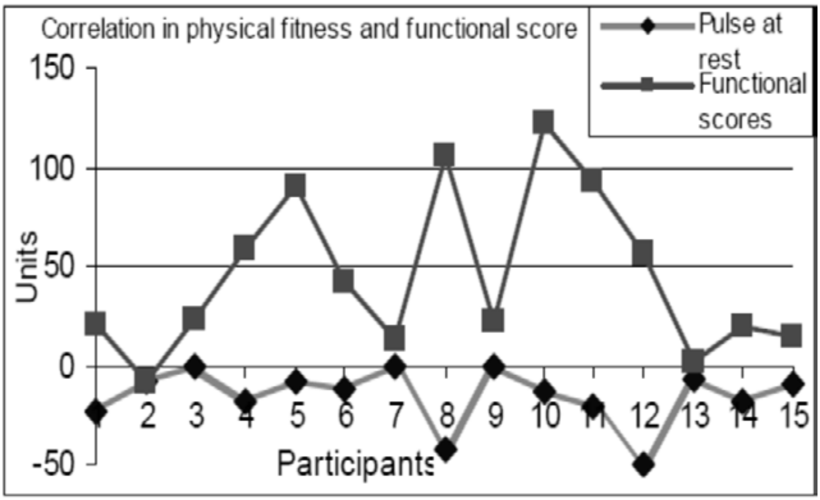

Figure 5. A correlation between change in pulse at rest and change in functional scores

Project 2

All measurements where calculated using a two-tailed, paired T-tests performed on an SPSS program 14.1.

- Pulse at rest decreased significantly (**P<0.05**) for the research group from 88.7 at program initiation to 81.6 at the end of one year of training. No change was observed for the control group (Figure 6).
- Pulse during exercise was only measured for the research group and was found to have decreased significantly (**P<0.0001**) from mean of 119 to the mean of 101 at the end of one year. (Figure 7).
- Infirmary visitations were significantly (**P<0.025**) reduced for the research group from 213 yearly visitations in the year prior to initiation of intervention, to 114 yearly visitations during the year of intervention. The control group visited the infirmary 207 times during the year prior to intervention and 220 times during the intervention year (Figure 8).

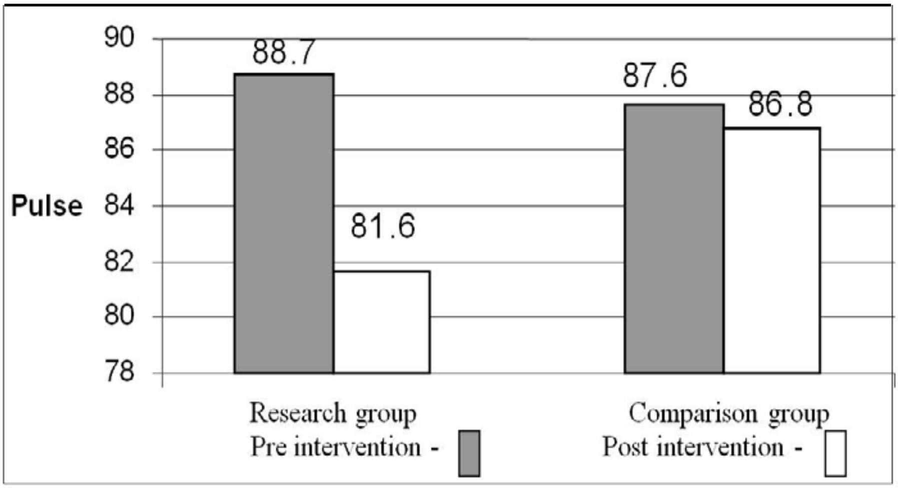

Figure 6. Pulse at rest comparison between research and comparison group

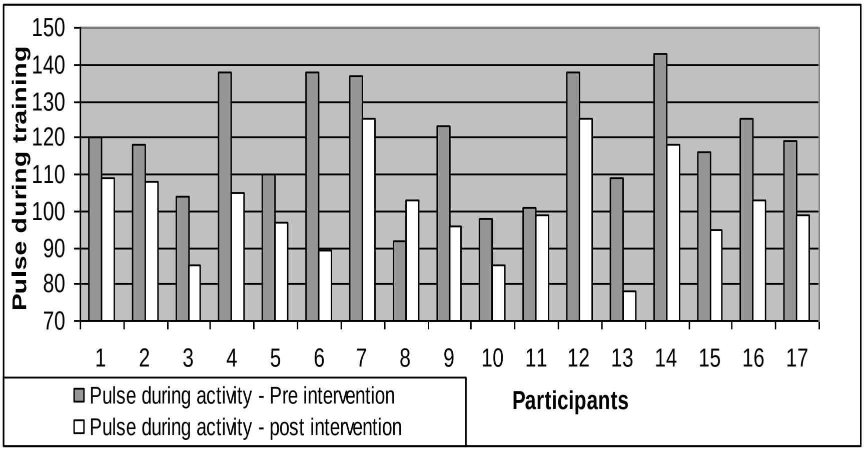

Figure 7. Pulse during exercise, research group pre-post measures

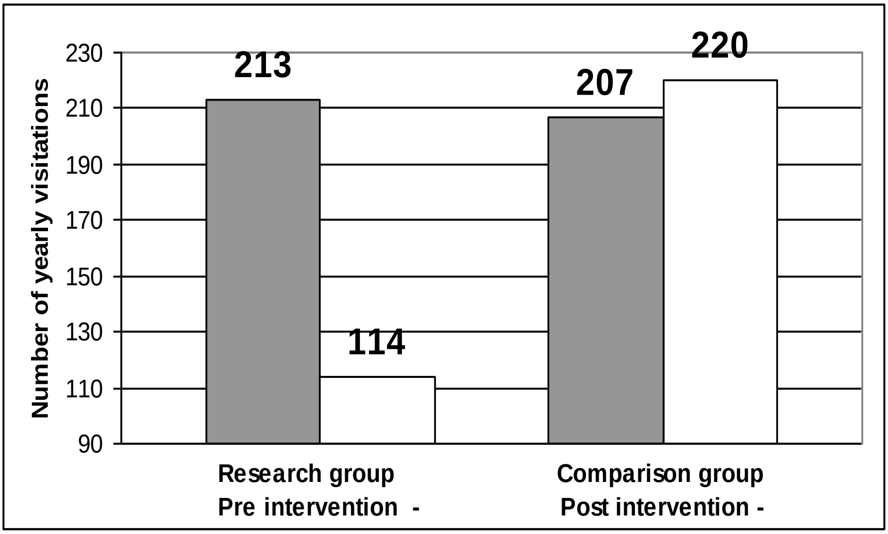

Figure 8. Visitation to infirmary pre-post measures

- A modest (**r=0.42**) but significant (**P< 0.008**) correlation was found between the drop in infirmary visitation and the reduction of pulse at rest.

Project 3

All measurements where calculated using a two-tailed, paired T-tests performed on an SPSS program 14.1.

- Pulse at rest – The participants (Numbers1-4 on each graph) displayed a mean of 83.4 resting pulse per minute pre intervention. mean pulse at rest for minute for all participants was found at 75.8 post intervention. This change was found statistically significant (**$P<0.05$**) and represents an average reduction of 7.6 heart beats per minute per participant over a month of training. The control participant (participant 5 at all graphs) did not show any change regarding the pre-post measurement of this parameter (Figure 9).
- Pulse recovery at end of training session- Mean heart rate immediately at the end of the first physical training session was measured at 119 for all four participants and was re-measured at post intervention at 108. This change was found significant ($P<$ **0.042**). Mean heart rate three minutes after first physical training session termination was measured at 109.5 for all four participants and was re-measured at post intervention on 95.5. This change was found significant (**$P<0.01$**). Results where very similar and consistent for all participants. The control resident on the other hand, showed non consistent result that bared no statistical significance (Figure 10).
- Muscle strength – The mean strength of the Glutius maximus (GM) muscle, of both legs, prior to intervention initiation, for all participants was measured at 2/5. Even though one participant did not show any difference in GM muscle strength at the end of the intervention period, three of the participants showed a consistent improvement in GM muscle strength. Thus the mean improvement for those three participants at the end of the intervention program was 3/5. The change in muscle strength was found significant **($P<0.01$)** in those three participants. The control participant showed no change whatsoever in muscle strength (Figure 11).

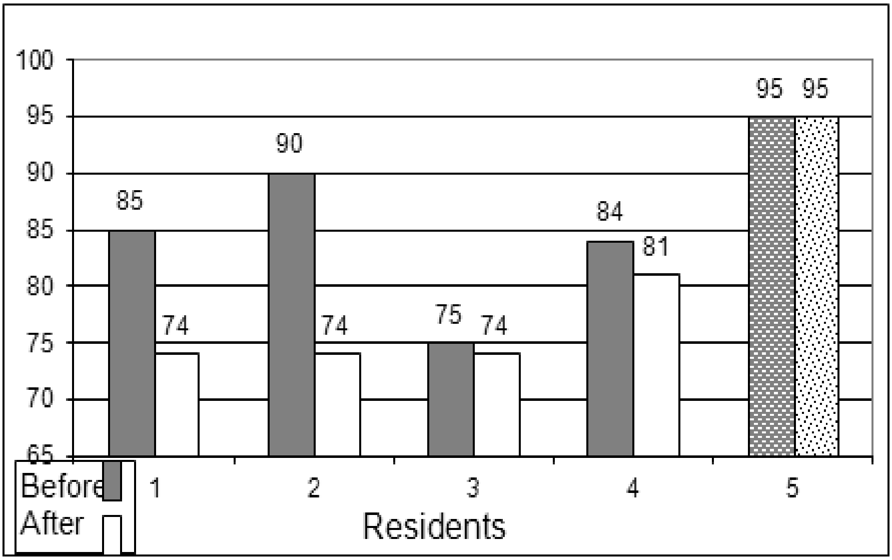

Figure 9. Heart rate pre-post intervention participants (1-4) & control (5)

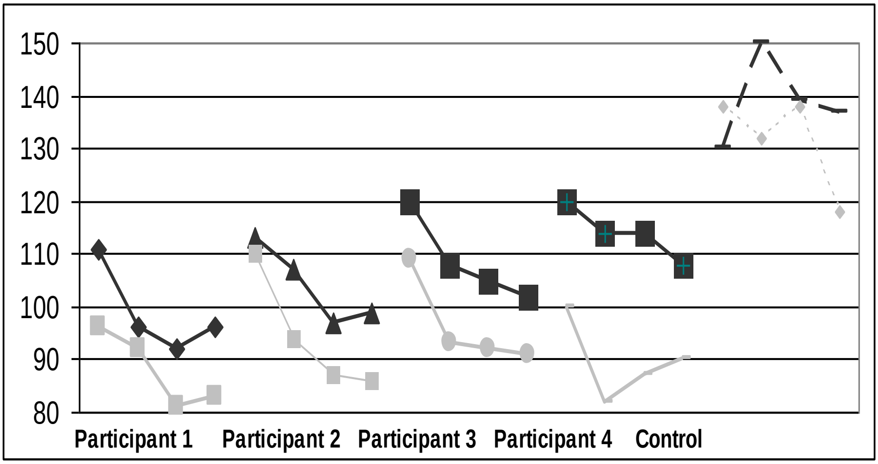

Figure 10. Comparison of heart rate recovery at end of training session, pre-post measurements, participants (#1-4) Vs. control (#5)

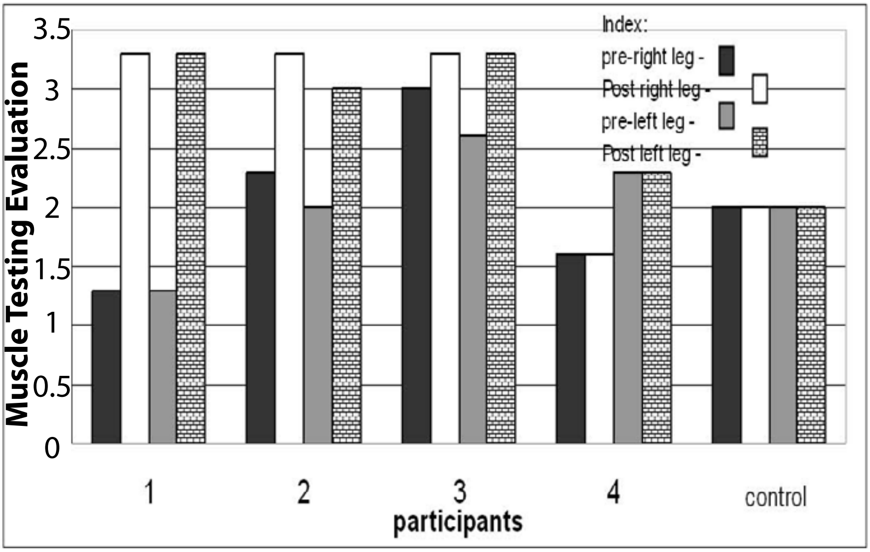

Figure 11. Pre-post muscle strength measurements of GM muscle, participants (1-4) Vs. control (5)

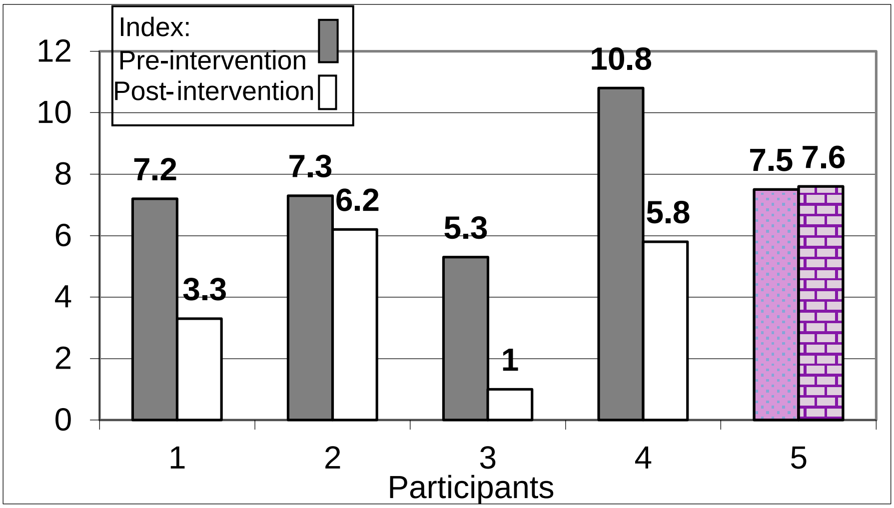

Figure 12. Pre-post task performance time measurements, research (1-4) Vs. control (5)

- Task performance – Mean task performance time which was measured at 7 minutes and 42 seconds at the beginning of the intervention program and was reduced at termination of program to 4 min. and 12 sec. This measure showed a constant and significant improvement (**P<0.025**) for all four participants. The control participant showed a small non significant change (for the worse) (Figure 12).

DISCUSSION

The present interventions were set to examine the feasibility and results of short term low budget intervention programs for individuals with IDD and the results highly support the implementation of such programs.

The presented programs evaluated the contribution of a low graded physical intervention program for children and older adults with cognitive impairment. Baseline, pulse measurements of the participant's at all three programs indicated very poor physical condition, thus exercise level at the initial point was low, and the ongoing progress was gradual.

- Results show that pulse at rest (correlated with aerobic fitness) and during exercise, dropped significantly as a result of all intervention programs, suggesting that at very low physical fitness (common among people with sedentary life style at all ages), even moderate intervention programs have a significant influence on physical fitness.
- Results show that a training program can cause a change in the participant's functional ability, and that this change is correlated with aerobic capacity. These results suggest that the poor functional ability of this population might be attributed, at least in part, to their poor physical state. Yet such assumption needs further investigation.
- The reduced infirmary visitation observed for the research group might suggest a possible perception of “ill well being” by participants prior to intervention, manifested by an exaggerated need for medical attention. The training programs might have caused a change in such perception, yet such assumption needs further investigation.
- The results shows that low graded, low cost, physical intervention has impressive results, with reduction in infirmary visitation which by

itself carry further medical implications (reduced costs of medical care).

The accumulated knowledge from the hereby presented programs as well as from similar intervention programs executed with many different groups with disabilities [38-43] in the past support each other. The vast array of evidence suggest that these results could be generalized to the all diagnosed with IDD.

Such promising results urge clinicians working with this population to encompass these individuals in physical activity programs that will improve their quality of life.

Another point in favor of similar programs can be drawn from the fact that several studies have shown that regular physical activity increasing muscular strength, endurance, flexibility, balance, cardiovascular and respiratory efficiency [48-50], decreases the level of assistance that nursing home residents need in order to perform activities of daily living (e.g., dressing, transfers, rising from chair, walking). Hence, in order to increase independence in individuals with IDD, even at old age, exercise programs should be available for this population with no regard to age.

More programs similar to this one should be able to expend our knowledge in this field, reveal the effect of such programs on larger and diverse groups of participants, and explore the long term effect of such programs.

The limitations of these intervention programs stem from the fact that participant number was small and intervention duration was short therefore the ability to generalize is hampered.

SUMMARY

The finding of the above mentioned programs suggest that a consistent physical intervention program, entailing walking could be extremely beneficial for children and adults with IDD at different functional and cognitive capacities. Such programs can enhance activity levels, muscle strength, aerobic capacity, and might even lead to significant improvements in independence, function, and medical condition of participants

These programs also showed that a cost effective intervention can be implemented for this population through the participation and support of volunteers with the supervision of a physical therapist. The importance of applying a rehabilitative approaches (in contrast to a maintenance approach), even with severely physically affected individuals with ID is here by reiterated.

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In: Physical Fitness: Training, Effects and… ISBN: 978-1-61728-672-8
Editors: Mark A. Powell

Chapter 4

EFFECTS OF CHRONIC LOW BACK PAIN ON PHYSICAL FITNESS

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ABSTRACT

Low back pain is a condition that greatly affects the physical performance of patients and represents today a major health problem, not only due to its physical and psychological implications but also because of the high costs in terms of treatment and sick-leave days. The level of aerobic fitness determines one's quality of life, to the extent that adequate fitness allows one to perform activities of daily living. A long-term pain-induced inhibition of activity like that induced by chronic low back pain may cause further physical deconditioning. This deconditioning can perpetuate the sensation of pain and create a vicious cycle from which the patient cannot escape.

For too long, rest has been the most frequently prescribed treatment in patients with low back pain. However, several scientific publications now acknowledge the importance of physical reconditioning in the rehabilitation of these patients, based on the hypothesis that they are deconditioned. The current trend is to treat low back pain using intensive

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physical training programs, although the measured values of physical fitness level in chronic low back pain patients are contradictory.

In this paper, scientific publications focusing on the measurement of aerobic capacity in patients with chronic low back pain are reviewed. Mechanisms by which physical deconditioning may contribute to the onset or chronicity of low back pain are discussed. Previous errors in the techniques and interference of limiting factors in the measurement of maximum aerobic capacity may explain the confusing results on physical fitness measurement. Lastly, some suggestions for individual exercise prescription and for future research in the field of reconditioning of these patients are made.

Low back pain is as old as mankind and now represents one of the most worrying health problems, not only because treatment is difficult, but also because of its health implications and the high costs of treatment. The highest prevalence of low back pain occurs in adults between 55 to 64 years, where it affects up to 32% of the population (Deyo 1987), constituting the second most common health problem after cardiovascular disease (Kelsey JL. 1980). Rural populations in developing countries, in which daily tasks are characterized by greater physical demands, have shown a lower prevalence of low back pain with values ranging between 0 and 18% (Voilin E.1997). However the urban populations of these same countries have similar values to those of industrialized countries. 28% of patients with back pain will seek disability from work (Black AR. 1982) making them responsible for 85% of the cost in lost work days, compensation and treatment (Nachemson AL. 1987). Of all patients who suffer from back pain, 10% will evolve into chronicity [Hall H.1990], a stage of the disease with severe functional and psychological implications since it is a condition for which a cure may be impossible.

Chronic low back pain has been defined as pain that exceeds six months, with lumbo-sacral location at the height of the iliac crests or lower, medium or lateralized, with the possibility of radiation to the leg and no tendency to improve (Duquesnoy B. 1994). In most cases, the pain is triggered or exacerbated by physical effort, leading the patient to avoidance and suppressive behaviors and consequently inactivity, even forcing bed rest. The effects of physical inactivity during prolonged bed rest have been described since ancient times by Hippocrates who reported deterioration of strength and physical performance (Chadwick 1950). This clinical picture, described today by Bortz (Bortz 1984) as "disuse syndrome" and by Mayer (Mayer 1985) as "deconditioning syndrome", has a negative effect on multiple physiological functions, leading to a vicious cycle in which inactivity and deconditioning are interconnected. Different terms have been used to describe the changes related to a decreased functional capacity in patients with chronic low back pain. Verbunt et al (Verbunt 2003) proposes the term disuse as “performing at a reduced level of physical activity in daily life," physical deconditioning as "a decreased level of physical fitness with an emphasis on the physical consequences of physical inactivity in the human body" and finally, disuse syndrome as “the result of long term disuse, which is characterized by both physical and psychosocial effects of inactivity”. Although the level of physical activity in daily life appears to be closely related to chronic low back pain, there is little scientific information available, and the available data are inconclusive, apparently because of the measurement methods used so far.

The ability of a person to perform the tasks of daily life depends on the level of performance of various physiological parameters, among which are endurance and muscle strength, cardiovascular and respiratory capacity, neural control of movement, flexibility and body composition. All above mentioned need a sufficient level of performance and to act synergistically and synchronously to ensure the realization of a proper physical work even at a level of athletic performance. Disuse induced by a decrease in physical activity affect the individual as a whole and ultimately leading to deconditioning and disuse syndrome. To address this specific issue in patients with chronic low back pain, skeletal muscle performance, maximal aerobic capacity and cardiac function will be the focus of this text.

In the musculoskeletal system, specifically in skeletal muscle, several harmful effects of deconditioning have been documented (Biolo 2005). In fact, the level of physical activity is a determinant of muscle performance including patients with chronic low back pain. Physical deconditioning might be suggested as a factor for exercise intolerance in patients with chronic low back pain, based on the association between physical inactivity and physiological processes that lead to muscular atrophy and reduced exercise capacity by peripheral muscle fatigue. Indeed, poor central command (Gandevia 2001), high levels of lactatemia, phosophocreatine depletion (Sahlin 1992), impairment in energy substrate supply (Sahlin 1998) and metabolic and structural disorganization of contractile proteins (Westerblad 2002) have been identified as responsible factors. For example, Phillips (Phillips 2009) believes that the unloading-induced atrophy is dependent almost solely on the loss of mechanical input. In cases of severe functional limitation as when the patient with chronic low back pain is forced to bed rest, muscle unloading leads, as shown in previous studies (Phillips 2009), to decreased rates of protein turnover in muscle with a predominance of inhibition of protein synthesis.

Nuclear magnetic resonance imaging has revealed over a period of one year a slightly smaller cross-sectional area of paraspinal muscles in patients with low back pain. The endurance of these muscles was compared between patients with chronic low back pain and healthy subjects by Hultman et al (Hultman 1993) who found significantly shorter trunk muscle endurance times in patients with chronic low back pain than in healthy controls.

The decreasing use of the muscles in their full range of motion also seems to be related to an increased stiffness and contractures due to the involvement of collagen tissue. This condition may be related to inadequate biomechanical performance in static postures such as standing or sitting positions and in dynamic activities as during walking and running. This conditions leads to contractions that decrease muscular blood output with a resulting decrease in oxygen supply, and a shift to anaerobic energy metabolism. Under these conditions, hypoxia and high concentrations of lactate in the muscle would play an important role in the occurrence of contracture and pain and decreased muscle performance. Additionally, compared with healthy subjects, muscle endurance in patients with chronic low back pain is impaired because muscle capacity is also associated with the level of daily physical activity. In this case, the reduction in activities of daily living of patients with chronic low back pain can lead to a loss of physical fitness by decreasing oxidative capacity and thus affecting the endurance of skeletal muscle and resulting in premature fatigue. For its part, the loss of muscle strength could be responsible for a significant limitation of working capacity in these patients, as has been demonstrated in patients with cardiopulmonary disorders (Hamilton 1995). Furthermore, low levels of force contribute to a diminishment of subject's participation in physical activities, both in work, leisure and sports, and can be a risk factor for accidents such as falls. Finally, this cluster of abnormal muscle performance could be also a risk factor for the onset and perpetuation of pain.

On the other hand, maximal aerobic capacity, as assessed by maximal aerobic uptake (VO_2max) is closely related to the level of exertion during physical activities that involve repetitive use of large muscles, such as walking, jogging and cycling. To date, this physiological variable is considered a reliable parameter for measuring a subject's functional reserve in health and in disease. High aerobic capacity in physically active subjects ensures adequate function in activities of daily living, employment and athletics. The most important adaptations related to high aerobic capacity are: increase in levels of beta-endorphins (McCain 1989), improvement of the sense of well-being (Nutter 1988), better health-related quality of life (Acree 2006), and the optimization of cardiovascular function (Convertino 1986).

Based on maximal exercise testing in healthy subjects, categories of aerobic capacity matched for age and gender have been proposed (Astrand 1956, Shvartz 1990), the VO_2max in women representing approximately 85% of that for men (Åstrand 1956) and higher values been considered an important factor in successful aging (Ginet 1995).

The losses in maximal aerobic capacity in patients with chronic low back pain have been reported by several authors (Duque 2009, Robert 1995, Nielens 1991, Smeets 2006) and its variation with inactivity represents a good index of the metabolic and cardiopulmonary consequences of the deconditioning process. If the intensity of pain is enough to force the patient to bed rest, the magnitude of the loss will be greater and will depend on the duration of confinement (Birkhead 1964, DeBusk RF 1983) and may reach 0.9% per day on extended bed rest (Convertino 1997). Although with the differences in methodology of estimating the value of VO_2max, several authors have shown low levels of aerobic conditioning in patients with chronic low back pain. In a previous study of patients with chronic low back pain using a test cycle until exhaustion, Duque (Duque 2009) found an average value of VO_2max equal to 30.8 ± 7.7 ml * kg^{-1} * min^{-1} (33.9 ± 6.7 and 27.2 ± 7.3 ml * kg^{-1} * min^{-1} for men and women respectively) equivalent in terms of fitness to that of healthy but poorly conditioned subjects proposed by Astrand (Astrand 1956), a lower level than that observed in sedentary subjects. Using also comparisons with healthy subjects, Nielens & Plaghki (Nielens 2001) and Smeets (Smeets 2006) also found low levels of aerobic capacity in these patients.

Since at present functional restoration programs through exercise have proved to be the best therapeutic choice for the treatment of back pain, VO_2max measurement plays a very important role as a tool for grouping the subjects before starting the training program, one of the current requirements for accurate exercise prescription. To ensure the best response to a functional restoration program and to prevent injuries during training a VO_2max-based training load prescription is necessary, as recommended by the American College of Sports Medicine (ACSM 2006).

Regarding cardiac function, both maximal and submaximal heart rates increase with deconditioning (Convertino 1997, Stratton 1994). Under these conditions, during the performance of physical tasks for a given value of VO_2 the subject needs a higher heart rate. From the standpoint of cardiac mechanisms involved, the decline of VO_2max is similar to that observed in cardiac output. During exercise, with an arteriovenous oxygen difference that remains unchanged, the slight compensatory increase in maximum heart rate cannot compensate the reduction in stroke volume which occurs with inactivity (Convertino 1997). With deconditioning, despite a higher heart rate, the value of VO_2 is lower. Under these conditions, higher levels of norepinephrine lead to increased sensitivity of β-adrenergic receptors (Engelke 1996) acting as a compensation mechanism to maintain cardiac output. The mechanism that could explain these responses is the increase in resting heart rate linked to a decrease in vagal tone and little alteration of sympathetic tone. Reduced physical activity and prolonged rest lead to an increase in heart rate with a decrease in VO_2, as the reduction in cardiac output and VO_2max are the result of decreased stroke volume. This decrease in stroke volume can be explained by the decreased cardiac output and increased heart rate during exercise with changes in venous return and cardiac filling representing the main mechanisms. Other cardiovascular effects of deconditioning are hypovolemia and decreased cardiac filling pressure and ventricular performance by atrophy (Saltin 1968). Given this decrease in stroke volume, increased ventricular ejection fraction is a compensatory mechanism (Convertino 1997). Concerning oxygen delivery, maximum utilization of oxygen in the muscle is impaired by greater accumulation of lactate (Williams 1988) and is affected by decreased muscle blood flow that is seen at rest and vascular muscle by decreased oxidative enzyme activity (Hikida 1989).

Until recently, rest has been the preferred treatment for back pain. But this treatment has proved to be only marginally successful, and that lack of success has provided an impetus to seek new therapeutic alternatives. Since physical deconditioning is one of the most detrimental phenomena that occurs with chronic low back pain, the development of an aerobic-capacity recovery program to slow the deconditioning process is needed. Interventions against rest and in favor of exercise in these patients were first proposed in the 1980s (Gibert JR. 1985, Newman R. 1987), most notably Nachemson (Nachemson 1983), who proposed "... Work for all. For those with low back pain as well." Functional restoration programs through physical exercise have been well recognized by health professionals for over 30 years (Kohles S. 1990) and have demonstrated, to date, to be the best alterative therapy for the treatment of pain back. These programs have been described as "intervention in a multidisciplinary tertiary care with a sports medicine approach that seeks the restoration of general physical capacity and a technical intervention for the treatment of cognitive handicap (Teasell RW. 1996). Programs vary in content and are available in most cases in a combination of progressive physical training programs, occupational therapy, cognitive behavioral therapy, work hardening and clinical psychology support. The importance of aerobic capacity in both in the physiopathology and treatment of low back pain has led to this physiological variable to be considered as a criterion of effectiveness of functional restoration programs. The objectives of these programs are primarily focused on reducing disability and psychological stress, improving general health and accelerating the return to work or activities of daily living. Some authors believe that the improving effect of the training program on aerobic capacity is crucial for the overall success of treatment and contributes, among others things, to an earlier return to work (Lindström I. 1992, Gatchel RJ. 1986). Other effects resulting from regular exercise in these patients are pain reduction, improvement of general physical capacity and decreased difficulty in performing daily tasks (McQuade K. 1988, Cinque C. 1989, Saal JA . 1988).

Evidence suggests that treating physically deconditioned chronic low back pain patients with intensive physical training provides numerous benefits. In addition to improving aerobic capacity, patients also demonstrate improvement in other determinants of physical performance (flexibility, muscular strength, and coordination). This improvement in multiple aspects of an individual's health is one of the most valuable aspects of such programs.

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In: Physical Fitness: Training, Effects and… ISBN: 978-1-61728-672-8
Editors: Mark A. Powell

Chapter 5

USING MENTAL TRICKS TO ENHANCE PHYSICAL FITNESS

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ABSTRACT

The goal of enhanced performance in sports and fitness training is an ancient pursuit. But using the mind to train itself, and adopting approaches to enable the mind to train the body, is a bold new enterprise.

The brain can be altered in direct response to pharmaceutical applications, surgical techniques, and sudden trauma. It can also be impacted through experience.

According to the most recent studies in neuroplasticity, the brain can be altered through sheer mental experience, in realms that are perceptual, emotional, conceptual, and social. If the experience is related to calisthenics training, the brain's altered structure can lead to a cascade effect in the larger physical organism, influencing muscular strength, coordination, and fitness function.

The basic result: if you can engineer the brain's experience, you can engineer the brain.

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The "experience" can be a real life experience, but it can also be simulated – an artificial condition, facilitated through a virtual reality experiment, perceptual deception, or sensory hoax.

A brief list of studies suggests the potential of mind-over-matter, the "matter," in this case, equating to the physical body. My own speculative article (DiPrete, 2008) touches upon the work of Ramachandran and others, and calls for more innovations in this particular line of research.

INTRODUCTION

The goal of enhanced performance in sports and fitness training follows an ancient pursuit. One notorious "short-cut" to this goal has included the use of steroids to push the athlete into an accelerated mode, short-circuiting the natural regimen of diet, good nutrition and focused exercise. Taking steroids is an illegal practice, one that compromises an athlete's health. Discovery of a more benign (and pragmatic) method to bolster human potential would offer a more adaptive, health-conscious alternative. Using the mind to train itself, and adopting approaches to enable the mind to train the body, would provide a more agreeable solution.

According to recent studies in neuroplasticity, the brain -- and the body -- can be altered through sheer mental experience, in a range of fascinating realms that include the perceptual, emotional, and social aspects of cognition.

If you can engineer the brain's experience, you can engineer the brain. The brain, in turn, can alter the internal structure of the larger human organism. The "experience" of the brain can be (and usually is) based on a real life experience. But it can also be the result of a simulated illusion – an artificial condition, the latter facilitated through a virtual reality experiment, perceptual deception, or sensory hoax.

A brief list of studies suggests the potential of mind-over-matter, the "matter," in this case, equating to the physical body. My own speculative article (DiPrete, 2008) touches upon the work of Ramachandran and others, and calls for more innovations in this particular line of research.

BACKGROUND

Studies of neural plasticity suggest that muscular strength can be increased by imagining a specific muscular exercise. For example: focusing on a specific mental task, such as lifting weights with a finger, gradually increases the finger's strength, endurance, and agility (Yue and Cole, 1992). "…when test subjects visualized themselves lifting weights with a particular finger over a certain period of time, the finger they had imagined lifting with actually became stronger" (as cited in Dispenza, 2007, p. 56).

Focusing on a specific mental task, such as lifting weights with a finger, gradually increases the finger's strength, endurance, and agility.

According to additional research (as cited in Doidge, 2007) the motor cortex is also stimulated by the act of seeing a body part, or illustrations of one. In the study by Yue and Cole (1992), stimulation of the motor cortex leads to a stronger body part.

If, in fact, the nature of this effect (imagining a specific muscular effort to increase muscular strength) remains unaltered if performed simultaneously during the exercise itself, then it's probable both exercise and imagination can be coordinated together to increase the effect.

Thus, seeing one's animated reflection in a mirror (implicating the Occipital lobe, and creating a mental imagistic condition) during the exercise should conjoin the exercise to a mental process similar to imagination, and should increase the benefits of such exercise.

Theoretically, seeing an enlarged representation of one's physical exertion, in a magnifying mirror, should increase the sensory impact of the exertion. Limb motions, magnified in perception, appear to span a greater spatial distance. The extension of an arm, for example, under magnification 2x, creates the illusion of increased speed.

The apparent size, and mass, of the limbs are similarly increased. Such physical actions depicted in sensory form should appear stronger, creating an illusion that one is performing more forcefully than one is actually performing. The neurological effect should be similarly strengthened, heightening the impact in stimulating the motor cortex as discussed earlier. Thus, the proportionality of effect is significantly enhanced.

The ideas expressed are theoretical (DiPrete, 2008) but trenchant to the aspects of this chapter. Ironically, the perceptual effect could be felt in its opposite form, if it relates to the size-weight illusion described in the paragraph that follows. (If such is the case, perhaps a *decreasing-magnification* mirror should be used, instead.)

The general idea -- sensory illusion to increase the effects of a physical exercise -- has been suggested by others, such as Ramachandran (2008) in *Scientific American Mind*. In the article by Ramachandran, a smaller suitcase weighing the same as a larger one is felt, or experienced, as weighing more. It is a common size-weight deception, described as the Charpentier-Koseleff illusion (1891). "...the implication would be that merely feeling excess exertion causes the brain to send more signals to the heart to raise blood pressure, heart rate and tissue oxygenation" (p. 20).

Could we conclude, then, that lifting a *smaller* set of barbells – as compared to lifting the same weight in a *larger* set of barbells – would more significantly increase one's lifting exertions, and hence the aerobic benefits? (In this particular case, perhaps *smaller* would be better.)

Doidge also describes the work of Ramachandran and others, as it relates to phantom limbs, pain reduction, and stroke rehabilitation. "Mirror therapy...fools the patient's brain into thinking he is moving the affected limb, and so it begins to stimulate that limb's motor programs" (p. 195). Thus, mirrors have been used before as therapy aids in motor control, though not in the manner as described here.

If the practice of exercising in front of a mirror -- especially a magnifying mirror -- increases the physical benefits, then a simple technique exists to enhance the quality of fitness training in sports. The principle could be used to increase the benefits of Olympics training, for example. Installing a set of large magnifying mirrors, in all sports training centers, could facilitate an increase in athletic improvement in a large-scale and cost-effective manner.

PROPOSED EXPERIMENT

Three groups of athletes, each group engaged in a similar exercise program, such as weight-lifting, would participate in a double-blind experiment. A simple upper-arm strength test would be administered to the members of each group at the beginning, and again at the end, of the month-long program.

The program setting, décor, time frames, etc. would be identical, except for the fact that for one group, large wall-mirrors of normal reflecting surface would face the members of that group during their exercise; in the second group, large wall-mirrors of reflecting *magnifying* surface would face the members of that group during their exercise; finally, in the third group, *no* mirrors would face the members of that group during their exercise.

At the end of the month-long experiment, strength gains (as determined by the strength test), would be compared to determine which group acquired the most upper-arm strength.

A similar experiment (without mirrors) could be performed using larger barbells versus smaller barbells, both of the barbells of the same weight, to determine if superior strength gains occur in the group using the smaller barbells.

EXPERIENCE AND ILLUSION

The internal, physiological, aspects of brain transformation, and the external ("experiential") aspects of brain transformation, appear to coincide. The result is a coalition of parallel and corresponding influence. The exploration of the brain's mental or conscious architecture (often the result of sensory data: perception, hearing and touch), in response to an experiential illusion, offers a promising frontier that could, perhaps, be manipulated – in artful fashion -- to produce profound neurological effects.

Reaction to input generated from the environment plays a central role in experience. The environment can be artificial or simulated, as long as the sensory (or psychological) inferences taking place in the recipient's mind appear to be actual, real, or meaningful.

The tools and approach of the artful simulator -- the manipulator of an artificial or virtual environment -- differ from the usual techniques associated with the psychologist's stock-in-trade. The most applicable skills for such expertise probably would be found in a Hollywood director or a stage magician -- or, perhaps, in a software or game designer. Popular examples of the latter include home entertainment simulations such as Microsoft's Flight Simulator and the Nintendo Wii console.

The interface of mind and experience creates a measurable, physiological alteration in the brain. If the experience is related to calisthenics training, the brain's altered physiology leads to a cascade effect that influences muscular strength, coordination, and fitness function in the athlete.

CONCLUSION

The range of possibilities that exist in the creation of tailored experiences, designed to create specific results in the brain, can be explored through the ingenious fruits of human imagination. The more tailored and realistic the experience is, the more interesting the results should be.

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In: Physical Fitness: Training, Effects and… ISBN: 978-1-61728-672-8
Editors: Mark A. Powell

Chapter 6

CAN ACTIVE VIDEO GAMES IMPROVE PHYSICAL FITNESS IN CHILDREN AND ADOLESCENTS?

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ABSTRACT

Maintaining good level of physical fitness (PF) is important to the health of children and adolescents. Unfortunately, many countries shown that children and adolescent's PF level was declining in the past decade and this declination was found to be associated with low level of physical activity (PA). Although insufficient PA was attributed by multiple factors, prolong exposure to screen-based activities (i.e., TV viewing and video game plays) was claimed as one of the major factors. Growing body of evidence has been suggesting that Active Video Game (AVG) play may be a promising tool to reverse this physically inactive lifestyle in children and adolescents. However, before applying AVG on PA and PF interventions, a better understanding on this emerging tool is essential. The purposes of this chapter are to provide an overview regarding the rationale and efficacy of applying AVG to promote PA and PF in children and adolescents. In additional, potential challenges for AVG research are also discussed.

INTRODUCTION

Maintaining good level of physical fitness (PF) is important to the health of children and adolescents. Previous studies (Boreham & Riddoch, 2001; Brunet, Chaput, & Tremblay, 2006; Burke et al., 2006; Ortega, Ruiz, Castillo, & Sjostrom, 2007; Rizzo, Ruiz, Hurtig-Wennlöf, Ortega, & Sjöström, 2007) have indicated that children and adolescents with higher PF level were at a lower risk of developing cardiovascular disease, diabetes, high blood pressure, obesity and mental illness (Hoeger & Hoeger, 2004; 2006) than their unfit counterparts. Unfortunately, many countries shown that children and adolescent's PF level was declining in the past decade (Tomkinson, Leger, Olds, & Cazorla, 2003; Wedderkopp, Froberg, Hansen, & Andersen, 2004).

There was consistent evidence indicating that the declination of children and adolescent's PF level was associated with low level of physical activity (PA) (Pate, Wang, Dowda, Farrell, & O'Neill, 2006; Ruiz et al., 2006). Although insufficient PA was attributed by multiple factors, prolonged exposure to screen-based activities (i.e., TV viewing and video game plays) was claimed as one of the major factors (Fox, 2004; Salmon, Timperio, Telford, Carver, & Crawford, 2005a). In this e-generation, screen-based activities have occupied considerable amount of children and adolescent's daily time (Gentile et al., 2004). On average, they spend 1.8 to 2.8 hours/day watching TV and 20 to 60 minutes/day playing video games (Daley, 2009; Marshall, Gorely, & Biddle, 2006; Vandelanotte, Sugiyama, Gardiner, & Owen, 2009). As time spending on these screen-based activities increased, the time that children and adolescent can allocate to the other activities including PA would inevitably be reduced (Durkin & Barber, 2002).

To reverse this physically inactive lifestyle, some studies (American Academy of Pediatrics Committee on Public Education, 2001; Vandelanotte et al., 2009) have proposed to limit children and adolescent's time spending on screen-based activities. However, the execution of this task may be challenging (Ni Mhurchu et al., 2008) because computers, TV, and video game consoles are already ingrained in different aspects of children and adolescent's daily lives (Fox, 2004). They are not solely used for entertainment, but also for learning, communication and social networking (Jansz & Martens, 2005; Yee, 2006). Moreover, there is no guarantee that children and adolescents would directly convert the reduced sedentary time to do PA (Salmon et al., 2005b). It is possible that the reduced sedentary time is allocated to the other kinds of sedentary activity like talking on phone, chatting and sitting.

If prohibiting sedentary screen-based activities seems not feasible, how about considering them as part of the solution for PA and PF promotion (Hillier, 2008)? Ni Mhurchu and colleagues (2008) have found that encouraging children and adolescents to play Active Video Game (AVG) like Nintendo Wii, Sony EyeToy and Konami Dance Dance Revolution (DDR) may be able to decrease their average time spending on all types of screen-based activity. More importantly, growing body of evidence has demonstrated that the energy cost during AVG was significantly higher than in resting and engaging in other sedentary activities (Maddison et al., 2007; Mellecker & McManus, 2008; Wang & Perry, 2006).These findings seem to support the usage of AVG on promote PA and PF in children and adolescents. However, before applying AVG on PA and PF interventions, a better understanding on this emerging tool is essential. The purposes of this chapter are to provide an overview regarding the rationale and efficacy of applying AVG to promote PA and PF in children and adolescents. In additional, potential challenges for AVG research are also discussed. Before the presentation of these issues, a brief introduction of the AVG is given in the following section.

AN INTRODUCTION OF AVG

AVG is defined as video games that used exertion-based interfaces to promote PA, fitness and gross motor skill development (Marc et al., 2009). The examples of such games that employ the exertion-based interfaces are Nintendo Wii, Sony EyeToy, and Konami DDR. Specially, the Nintendo Wii used a wireless hand-held controller (Wiimote) as the input into the virtual environment. The Wiimote is equipped with a sensor to detect movements of the players when they swing or wave the Wiimote, the system will then map the motions into the virtual environment.

Sony EyeToy does not equip with any hand-held controller. It has a small motion-sensitive USB camera which connects with the PlayStation 2 hardware and places on top of a TV. When players stand in front of the TV, the camera can capture and display their images on the screen. Then, the players can use any part of their body to move and manipulate the virtual objects displayed on the screen.

Konami DDR consists of a sensor footpad. When the players stand and dance on the footpad, it will detect whether the steps made by the player are matched with the dancing cues (i.e., direction of the steps) given by the system.

RATIONALES OF USING AVG TO PROMOTE PA AND PF IN CHILDREN AND ADOLESCENTS

AVG is defined as video games that used exertion-based interfaces to promote PA, fitness and gross motor skill development (Marc et al., 2009). During game play, children and adolescents can stay physically active while entertaining at the same time. When children and adolescents find performing PA by using AVG enjoyable, interesting and satisfatory, their intrinsic motivation to participate in PA may increase (Ryan et al., 2006). According to the Self-Determination Theory (Deci & Ryan, 1985, 2000), intrinsic motivation is the primary drive to PA behaviours. When children and adolescents are intrinsically motivated to perform PA by using AVG, they will be more likely to become physically active for their own sake, and make PA a habit (Nagle, 2009). Several characteristics of the AVG are suggested to facilitate player's intrinsic motivations for participations:

Fantasy. It is defined as the active use of imagination (Baranowski, Buday, Thompson, & Baranowski, 2008). In the virtual game environment, player's actions are not restricted by personal ability. This may encourage the players to perform the actions that they seldom do (i.e., adventure) or not able to do (i.e., fly in the air) in the real world. This characteristic of the AVG may stimulate player's curiosity, and thus motivate them to engage and adhere in the game environment (Baranowski et al., 2008).

Immersion. Player's attention is fully captured by the games and they are literally and emotionally involved in the game, as if they are part of the game environment (Baranowski et al., 2008). To increase player's sense of immersion, the games should be able to capture their attention. It can be done by providing appropriate level of challenge (Penelope & Peta, 2005). In the AVG context, PA is presented in a competitive game format. Players have to compete against other digital opponents (i.e., Wii boxing requires the player to battle with the digital opponent) or complete the challenges within limited period of time (i.e., EyeToy Wishy-Washy asks the player to clean as many windows as they can in a limited period of time). These competitive tasks require more attentions from the players than performing a simple repetitive task (i.e., doing sit-up for 10 times during workout). Moreover, AVG transforms the traditional PA venue (i.e., basketball court and sport stadium) into a virtual environment. The players may perceive the virtual environment as a novel stimulus because it is not a usual venue for them to perform PA. To respond to the novel stimulus, they have to allocate more attentions on it (i.e., increased duration of viewing) (Daffner et al., 1998). Furthermore, the players can see their movement on the TV screen directly and synchronically. This type of real-time feedback may also help to attract player's attentions, because they would want to regulate their movement so as to improve their in-game performances (Butler & Winne, 1995). The AVG also allows the players to control the digital avatar by gross motor movement which allows them to enter the fantasy world physically (Bianchi-Berthouze, Kim, & Patel, 2007; Ermi & Mäyrä, 2005). This physical sensation may reinforcing player's sense of control and enhance their sense of immersion to the AVG.

In addition, the AVG may help to attenuate the impact of environmental PA barriers, such as safety concerns. In contemporary society, parents tend to prevent their child from playing in outdoor areas for many safety reasons. For instances, kids may not be aware of the traffic or being abuse by strangers (Medina, 2008). These potential dangers may restrict children and adolescent's activity area to indoor venues, mostly the home setting. However, due to the limited space, most activities that can be performed at home are sedentary (i.e., watching TV, surfing on the internet and playing video games) (Hillier, 2008). Therefore, developing viable and effective strategies to increase children and adolescent's PA opportunity within the home setting is of paramount importance. The AVG consoles are small in size which can be easily installed in home. This strategy may help to transform the traditional sedentary home setting into a convenient PA venue with safe environment and warm atmosphere (Hume, Salmon, & Ball, 2005).

The Effects of AVG on Promoting PA and PF in Children snd Adolescents

Between year 2000 to 2008, studies related to the effects of AVG on children and adolescent's PA and PF have been growing rapidly (Dieterle, 2009). The findings of these studies were summarized and analysed in two recent review articles (Daley, 2009; Foley & Maddison, 2010). In the review articles of Daley et al (2009) and Foley and Maddison (2010), twenty-five journal articles and conference abstracts published before December 2008 were examined. Among these, seventeen studies assessed children and adolescent's energy expenditure (EE) during AVG. There were consistent findings indicating that children and adolescents spent significantly more energy during AVG than resting and hand-held video games. Two studies demonstrated that participant's EE during AVG increased by 120% to 400% from resting EE (Maddison et al., 2007). When compared to hand-held video games, participant's EE increased by at least 51% (Graves, Stratton, Ridgers, & Cable, 2007). Eight studies examined the effects and feasibility of employing AVG as an intervention mean to promote PA and PF in children and adolescents. The majority of these studies found that AVG-based interventions increased daily PA level and reduced time spending on the other sedentary video games in children and adolescents.

In summary, these findings supported that AVG is type of PA. It is because AVG involves gross motor movements (large muscle activity) and the energy expenditure when playing the AVG is significantly higher than resting EE level. Moreover, AVG had positive effects on promoting PA and PF in children and adolescents.

Nonetheless, some researchers have claimed that the intensity of AVG is insufficient to improve health-related fitness components, particularly for cardiovascular fitness. The majority of the existing AVG are categorized at low intensity (<3 METs), which do not meet with the moderate intensity (3-6 METs) recommended by the international guidelines for improving cardiovascular fitness (US Department of Health & Human Services, 2000). The possible explanation is that most of the AVGs mainly involve upper limbs movement but little locomotion (Miyachi, Yamamoto, Ohkawara, & Tanaka, 2009). This is supported by the findings of Maddision's study (2007) who examined children's energy cost during five Eyetoy AVGs (Knockout, Homerun, Dance UK, AntiGrav, and Groove). The results illustrated that only the three AVGs that involved certain level of horizontal locomotion achieved moderate intensity (Knockout=5.0 METs, Homerun=4.8METs, Dance UK=3.9 METs). Based on these findings, the AVG designers may have to strengthen the locomotion elements of the AVG (i.e., jumping and running) before it could be considered as a mean for PF interventions.

However, does it mean that the AVG have no further contribution to children and adolescent's PF before new technologies emerge? Does it mean that those low-intensity AVG are solely an entertainment tool like traditional hand-held video games? This may not be the case. In fact, the AVG might have more significant effects on improving skill-related fitness components. The possible mechanism is that AVG is a target-based activity (similar to action video games), in which players have to response to dual or multiple targets or objects at one time (i.e., players have to hit the opponents accurately while evading from his attack at the same time in the Eyetoy Knockout game). Green and colleagues (2006b) found that repeated exposure to action video games could improve children and adolescent's visual attention ability. This represents that they can identify and locate more objects at a time more quickly and accurately. Likewise, frequent repetition of this task may also increase short-term memory skills. Better short-term memory increased the accessibility of the movement cues, thus individual could make quicker musculoskeletal response (Green & Bavelier, 2006a). This explains why AVG may possibly improve eye-hand coordination performance, reduce reaction time and increase movement speed. Improved skill-related fitness components also have positive effects on children and adolescent's motor competence. Improved motor competence was associated with higher PA self-efficacy, which means that children and adolescents would be more confident about their ability to perform PA (Cantell, Crawford, & Doyle-Baker, 2008). According to the Social Cognitive Theory (Bandura, 1977; Bandura, 2004), self-efficacy is a core element for enhancing PA motivation. Consistent evidence (Ward, Saunders, & Pate, 2007; Weiss, 2000) has been suggesting that increased PA motivation was associated with higher PA and PF level in children and adolescents. However, further experimental studies and randomized control trials are needed to verify these speculations.

POTENTIAL CHALLENGES FOR AVG RESEARCH

Although evidence seems to support that AVG is an appealing intervention tool for PA and PF promotion, a number of issues needed to be addressed before AVG can be widely applied to PA and PF interventions for children and adolescents.

The first issue is how to integrate AVG into PA and PF interventions. Researchers generally agreed that AVG is not and should not be used to replace authentic sports (Daley, 2009). The reason is that the intensity of AVG is far less from the real sports that they simulated to (Graves et al., 2007). In addition, AVG can not imitate and replace the human-to-human (i.e., communication and cooperation skills) and human-to-natural environment interactions (i.e., interactions that children and adolescents can experience in authentic sports) (Kretschmann-Kandel, 2008). So, does it mean that AVG and authentic sports are opposed to each other? Rather, they can be in complement relationship. For instance, low engagement and adherence rate have been reported as common problems in traditional PA and PF interventions for children and adolescents (Marcus & Forsyth, 2003; Ward et al., 2007). One of the possible explanations is that children and adolescents who are physically inactive may have negative PA experiences (Allender, Cowburn, & Foster, 2006; Sallis, Prochaska, & Taylor, 2000; Taylor et al., 2000). These negative PA experiences may have an adverse effect on their motivation to participate in the interventions (Bandura, 2004). In this context, the AVG seems to be an ideal motivational tool because it can be used as an entry point to provide fun and enjoyable PA experiences to children and adolescents. This helps them to regain the interest to PA and subsequently enhance their motivation to PA (Bandura, 1977; Bandura, 2004).

The second issue is that a dedicated person (i.e., teacher or parent) should be involved throughout the interventions (Kretschmann-Kandel, 2008) to facilitate children and adolescents to develop appropriate perception to AVG that it is an alternative for making up unmet daily PA goals instead of replacing the authentic sports. It is also essential for the dedicated person to assist the players to transfer the enhanced PA motivation from the virtual reality to the real life setting, and thus turning PA as a lifelong habit (Kretschmann-Kandel, 2008). Previous AVG-based interventions were mainly implemented on a self-helped basis where participants were provided with the AVG consoles to play at home (Murphy, Bondre, & Shields, 2009; Ni Mhurchu et al., 2008) or school (Kim, 2006; McDougall & Duncan, 2008). Therefore, whether a dedicated person could have extra benefits to the intervention remains equivocal. Future studies that comparing the effects between self-help and monitored basis are encouraged.

The third issue is the safety concern. When AVG is widely promoted as an alternative to authentic sports, we may anticipate that players may use it for a prolonged period of time. Parents have been concerning whether prolonged exposure to AVG would cause adverse effects to their child's health (i.e., strained eyes and motion sickness) (Oxley, 2008). Meanwhile, media reports and studies related to AVG injuries, such as Wiitis, Wii knee and Wii shoulder have been increasing recently (Cowley & Minnaar, 2008; Hirpara & Abouazza, 2008; Nagle, 2009). One study (Pasch, Bianchi-Berthouze, van Dijk, & Nijholt, 2009) has suggested that these injuries may attribute to the wrong perceptions to AVG. Children and adolescents may perceive the AVG as a fun game or a leisure activity but not a type of PA. Hence, they tend to neglect the warm up. Moreover, when they are too immersing in the game, they may overlook the duration of game play, potential dangers from the surrounding areas and the physical demand from the game (Penelope & Peta, 2005). This evidence has indicated that facilitating the players to develop proper perceptions to AVG and establishing safety guidelines are essential. Without addressing these issues, the potential of applying AVG on PA and PF interventions for children and adolescents may be undermined.

CONCLUSION

There is sufficient evidence indicating that AVG can contribute to daily EE and PA in children and adolescents. However, most of the existing AVG are not intense enough due to insufficient horizontal locomotion. This limitation may undermine the efficacy of AVG on improving health-related fitness components such as cardiovascular fitness. Nevertheless, AVG is an effective tool for improving visual attention ability. Therefore, AVG may have more significant effects on enhancing children and adolescent's skill-related components, such as eye-hand coordination, reaction time and movement speed. Currently, evidence has been focusing on the potential benefits of AVG on children and adolescents' cardiovascular fitness. Future studies are suggested to provide more comprehensive investigations on the efficacy of AVG on other PF components, such as muscular strength, muscular endurance, speed, and reaction time. This would provide valuable information for the researchers to select appropriate AVG to meet with different intervention objectives. In addition, future studies that examining the role of AVG in PA and PF interventions and establishing safety guidelines are also recommended.

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In: Physical Fitness: Training, Effects and… ISBN: 978-1-61728-672-8
Editors: Mark A. Powell

Chapter 7

STAYING FIT DURING AND AFTER PREGNANCY*

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ABSTRACT

Physical activity is vital for overall health maintenance, particularly cardiovascular health. Additionally, physical activity is important for decreasing the risk of cancer and osteoporosis in women. Physical fitness, a benefit of physical activity, is important during pregnancy and postpartum periods for both women and their babies. As women became more aware of this issue, their participation in physical activity increased. Upon becoming pregnant, many women posed their Ob/Gyn physicians with the question, "is physical activity during pregnancy safe?" Initially, little was known about the effects physical activity had on the expectant mother or fetal development. Research has led to a better understanding of maternal and fetal physiology and findings highlight the importance of physical activity during this time. This chapter provides an overview,

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* A version of this chapter was also published in *Aerobic Exercise and Athletic Performance: Types, Duration and Health Benefits*, edited by David C. Lieberman under the title of *Physical Activity and Women: Unique Issues*, published by Nova Science Publishers, Inc. It was submitted for appropriate modifications in an effort to encourage wider dissemination of research.

which examines aspects of physical activity in regard to pregnant and lactating women. Based on the available literature, physicians have shifted their focus from assuring patients that physical activity during gestation is safe to encouraging physical activity during pregnancy because of the potential benefits to both the fetus and mother. Ultimately, these benefits are realized at labor and delivery and during the mother's recovery period. Current research into the fetal and neonatal benefits of maternal physical activity is explored. Lactation represents a continuation of the pregnancy, as the mother continues to supply nourishment for her infant. The effects of physical activity during lactation are viewed from the maternal and infant perspective. As research advances, American College of Obstetricians and Gynecologists (ACOG) guidelines continue to reflect these gains in information. Lastly, the chapter expresses what has been done, and what is currently being done to encourage women to stay physically active throughout their reproductive lifespan.

INTRODUCTION

Since the 1930's, women's attitudes about physical activity have gone through a dramatic, intellectual transformation. Over the last half century, women have started to take a more intentional approach in respect to their physical activities. For instance, many women participate in competitive sports. Large numbers of females engage in club sports and recreational activities. These increases in opportunities for women to be physically activity have generated a dramatic and positive shift in the health consciousness of women.

Many of the women engaging in physical activity pursuits are of reproductive age and plan to bear children at some point in their lives. The question often arises about the safety and benefit of engaging in physical activity during pregnancy. Additionally, women wonder what effects physical activity has on lactation. Consequently, there is a growing field of interest in the scientific literature focusing on physical activity during periods of pregnancy and lactation. Furthermore, researchers in this area are examining the benefits of physical activity during pregnancy to the fetus and the newborn child.

Physical Activity during Pregnancy

Starting in the 1960s, researchers around the globe began to investigate the relationship between physical activity and pregnancy (Sazontov et al 1952, Von Rutte et al. 1951, Bader et al. 1955, Hart et al. 1956). Initial research focused on examining the effects of physical activity prior to pregnancy and focusing on changes that were teratogenic, or harmful, to the fetus. Physical activity results in acute cardiovascular, hormonal, nutritional, thermo-regulatory, and biomechanical responses. There was concern these acute responses could have an impact on the developing fetus. The acute responses with exercise may apply to females who were physically active or sedentary prior to their pregnancy. Long term, consistent exercise leads to biochemical, physiological, and metabolic changes. These changes apply to exercise trained pregnant women.

Initial studies in the 1950s focused on the critical issue of hemodynamic responses of uterine blood flow during aerobic exercise in pregnant mothers. In the non-pregnant state moderate aerobic exercise causes vasoconstriction of splanchnic blood supply, which supplies the uterus, and vasodilation of vessels supplying working muscle. This causes a decrease in blood flow to the uterus of about 50% which could affect the developing fetus (Clapp 1978). Therefore, physical activity during pregnancy was thought to be detrimental to fetal health and development. Although research studies have differing results depending on exercise regime and measuring techniques, the current consensus is that blood flow to the utero-placental bed decreases during a pregnant mother's exercise. However, this decrease is not as great as in the non-pregnant state and is accompanied by other adaptations. For example, oxygen transport capacity is enhanced by increases in cardiac output (Clapp 2003, Weissgerber). Additionally, maternal blood volume increases to maintain an adequate nutrient supply to the developing fetus (Clapp 2003, Hart et al. 1956, Morrow et al. 1969). Exercise training during pregnancy increases resting maternal plasma volume, intervillous space blood volume, and red cell mass (Clapp 2003, Hytten and Chamberlain 1991). Other adaptations specific to the placenta occur and will be discussed later.

Typically, catecholamine levels decrease during pregnancy (Metcalfe et al. 1988). However, an exercise bout leads to a release of norepinephrine. Physicians were concerned that this change in hormonal milieu may affect the smooth muscle contractility of the uterus. Research has shown that the hormonal changes during exercise do not alter the endocrine milieu greatly during pregnancy. In the last trimester of pregnancy, levels or norepinephrine are diminished compared to the 1st and 2nd trimesters and to non-pregnant controls (Bonen et al. 1995). Upon the completion of exercise, hormone concentrations rapidly return to normal as in the non-pregnant state. (Bonen et al. 1995). None of the studies noted any increased incidence of uterine contractions or pre-term labor indicating the catecholamines do not have a stimulatory effect on the quiescent pregnant uterus. Therefore, catecholamine levels are similar in pregnant and non-pregnant exercisers and have little affect on the pregnancy in general even though norepinephrine can cross the placental barrier (ref). Thus, hormonal changes due to exercise do not compromise the developing fetus. The potential direct effects of catecholamines on the fetus will be discussed later.

Other exercise hormones, insulin and glucagon, are important for maintaining cells' metabolic demands for energy. Exercise promotes increases in glucagon and decreases in insulin (Gollnick 1985). This effect causes an intensity-dependent, hyperglycemic response to supply glucose to working muscle (Clapp and Capeless 1991). During pregnancy, though, insulin levels are elevated in order to maintain glucose delivery to the developing fetus (Metcalfe 1988). When exercise is combined with pregnancy the release of insulin becomes progressively decreased as gestation continues (Clapp and Capeless 1991). As the pregnancy progresses, a women normally becomes more insulin resistant in order to shunt blood glucose to the fetus, thus leaving maternal cells to use free fatty acids for fuel (Hytten and chamberlain 1991). Eventually the response of the pregnant mother to exercise becomes hypoglycemic instead of hyperglycemic and is no longer related to intensity (Clapp and Capeless 1991). A mother's glycemic response to exercise is influenced by whether she has ingested a high-glycemic or low-glycemic carbohydrate diet (Clapp 1998). Since there are so many factors that influence maternal glucose response (frequency, intensity, time, type of exercise, glycemic load of carbohydrates, women training status, etc.) there is not a defined response for blood glucose during pregnancy and exercise. Nonetheless, there is no evidence suggesting growth restriction of the fetus when exposed to maternal exercise (Clapp and Capeless 1990, Lokey et al. 1991). This is due to increases in dietary intake of food to maintain or increase availability of substrates and precursors for fetal-placental metabolism (*Weissgerber TL* and *Wolfe LA*) Hence, there are compensatory mechanisms to maintain fetal substrates for proper growth and development.

Another area of concern relates to the known physiological effect of hyperthermia during exercise and the potential teratogenic effect on the fetus. Depending on the intensity and environmental conditions, exercise can cause an increase of 1 to 3 degrees Celsius while 1.5 to 2.5 degrees Celsius is a known teratogen in some animal models (Clapp 1988, Metcalfe et al. 1988, Rowell 1974, Rowell 1983). The concern was that similar mechanisms would lead to harm for the fetus during maternal exercise. A normal compensatory mechanism of pregnancy is a lower body temperature (Clapp 1993). This lower temperature maintains a heat gradient away from the developing fetus. Additionally, the mother has increased blood flow to the skin during exercise (Clapp 1993). These adaptations are coupled with a lower sweating threshold to improve heat dissipation (Clapp 1993). Throughout the pregnancy, increased heat from exercise will be efficiently removed from the fetus.

During exercise there can be increases in stresses on joints and other portions of the body. Little was known about the effect of these forces on the growing uterus. Furthermore, as the pregnancy progresses, the expanding uterus changes a woman's body mass distribution, center of gravity, and increases joint laxity. The two questions raised concern whether these stresses from exercise during pregnancy could jeopardize the pregnancy (i.e. rupture membranes, preterm labor, injure the fetus) and whether it increases the mother's chances of injury. However, research has found no increase in spontaneous abortions or placental abnormalities. Studies looking at various exercises, including high impact activities, have demonstrated no differences in spontaneous abortion, malformations, placental complications (i.e. placenta previa), or pregnancy induced hypertension between exercising and non-exercising mothers (Clapp 1989, Clapp 1993-ch.2). As far as maternal injury, studies have not been able to find maternal injuries associated with exercise (McNitt-Gray 1991, Karzel et al. 1991, Work 1989). Many of the initial concerns with exercise during pregnancy were found to have no merit.

Outside of the acute affects of exercise on pregnant women, question has been raised about the chronic adaptations to exercise such as: cardiovascular, biochemical, and metabolic alterations. Exercise adaptations of the cardiovascular system include increased stroke volume and cardiac output at a given heart rate, increased plasma volume, and resting venous capacitance (Clapp 1988, Hytten and Chamberlain 1980, Rowell 1974). These adaptations are beneficial during pregnancy and allow for an increased heart rate reserve during exercise and may be a reason for the attenuated decrease of exercise induced uterine blood flow (Clapp 1990). Whether these known positive changes, such as improved maternal heart and vascular function, can improve pregnancy complications such as gestational hypertension is a current area of research. Various biochemical parameters change in response to regular physical activity such as: alteration of phospholipids composition, antioxidant status, and immune responses. Exercise changes the phospholipids fatty acid composition, which allows for improved insulin sensitivity (Borkman et al. 1993). Although the exact role this plays in maternal glucose metabolism is unknown, the fetal supply of glucose is maintained (ref). None of these biochemical changes has been shown to detrimentally affect the health and well-being of the developing fetus. Lastly, question has been raised about how gross anatomical changes that result from regular maternal exercise affect the pregnancy. In general, women who exercise regularly have decreased fat deposition. A decrease in the thickness of the panniculus adiposus may seem to put the fetus at increased risk of blunt damage by removing this cushioning layer, but this is not the case. As mentioned previously, the mother adjusts her eating to maintain her body weight and the energy requirements of the pregnancy. Exercise helps mothers use insulin to shuttle glucose into cells while still maintaining the level of glucose available for the baby. In this respect, exercise does not put the fetus at increased risk for trauma from blunt damage or for energy deprivation.

Early research demonstrated that the maternal body compensates well to acute bouts of exercise. Additionally, many physiological adaptations of exercise are beneficial to the pregnant women as well. Finally after many years of research, physicians can feel confident telling patients that exercise during pregnancy is safe.

Outcomes of Pregnancy Exposed to Exercise

Various studies have looked at pregnancy outcomes from mothers who exercised during pregnancy. Some parameters which have been measured are neonatal morbidity, APGAR scores, and fetal measurements. To date, no differences have been noted in neonatal morbidity from maternal exercise (Collings et al.1983, Hall and Kaufmann 1987, Kulpa et al. 1987, Sibley et al.1981). Even if exercise training was initiated during the pregnancy there is no increase in neonatal morbidity. Another important indicator of neonatal health is the Apgar score. The APGAR test rates five components of neonatal health: Appearance (skin color), Pulse (heart rate), Grimace (reflex irritability), Activity (muscle tone), and Respiration (breathing rate). Studies have shown no differences at birth in neonates exposed to exercise versus those who were not exposed to exercise in utero.

Ob/Gyn physicians tracked common fetal measurements (head circumference, body length, birth weight, etc.) in order to determine if exercise during pregnancy affected fetal growth and development. Head circumference and crown-heel length show no variation in infants whether exposed or not to exercise (Clapp 1990). The measures that show great variation are birth weight, percent body fat, and ponderal index. The ponderal index, similar to the body mass index concept, is a way of expressing the relationship of height to body mass. Therefore the main differences of infants exposed to exercise relative to their non-exposed counterparts are their birth weight and percent body fat. In general, a woman who continues exercise throughout the duration of her pregnancy will have a lighter infant. The decreased weight of the infant is due solely to decreased body fat (Clapp 1990). However, if a pregnant mother exercises during the first and second trimesters only and discontinues her regimen in the last trimester then the birth weight is similar to non-exercise exposed infants (Clapp 1990). Again these differences in birth weight are due to the change in fat deposition. Exercise studies show that pregnant women who eat more refined carbohydrates and sugars had fatter babies relative to pregnant mothers who ate whole grains and vegetables. Additionally, if the exercise regime is maintained in the third trimester, when the energy requirements are greatest for the fetus, the baby is often born lighter as a result of decreased fat storage. While maternal glucose is used for working muscle and this glucose is also the fetuses' first source of energy, research has shown that, with a relative maintenance of blood supply, the baby's increased ability to extract glucose is maintained. The last trimester of pregnancy is the critical period for fetal fat deposition and exercise, as well as different food intake, both of which can affect the amount of fat tissue the infant has at birth. For example, Clapp et al found that if a mother maintained exercise in the third trimester, the infant had a decreased body weight at birth due to decreased fat deposition relative to other baby's not exposed to exercise. When mothers decreased or stopped exercise during the last trimester, the baby's body weight was the same or increased due to a change in fat deposition relative to same age counterparts. Other factors can affect pregnancy outcomes, such as on the frequency, intensity, time, and type of exercise, and level of training prior to pregnancy.

Based on the findings that exercising mothers tended to have lighter babies, research was done into whether leaner or fatter babies were healthier. Clapp et al (1998) has demonstrated that children exposed to exercise in utero are morphometrically similar to counterparts at one year. Parameters compared among the two groups included weight, length (height), percent body fat, head circumference, chest circumference, and abdominal circumference (Clapp et al. 1998). However, in a different population of women, Clapp found children exposed to exercise in utero were leaner at five years of age compared to their counterparts who had not been exposed to exercise in utero (Clapp et al. 1996). However, past one year of age, it is difficult to determine if the effects are from nature (in utero exercise exposure) versus nurture (raised in a health conscious household) or a product of both. While the relationship between long-term leanness and maternal exercise while pregnant is still being elucidated, research has consistently found no negative impact of exercise exposure in utero on fetal development. In light of the childhood obesity pandemic, the decreased fat deposition may be a potential benefit to the children in the future.

Maternal Benefits

During the course of the research with pregnant women, some researchers noticed that many of the healthy pregnant volunteers had fewer complaints during pregnancy, which lead to investigation of the potential benefits received by the mother from exercise during pregnancy. Common ailments of pregnancy include back discomfort, difficulty with some movements, swelling, and anxiety. Researchers found that women who exercised during pregnancy had less pregnancy related complaints relative to their counterparts. There are varying hypotheses for what accounts for this relationship. It could be that exercising mothers actually had less aches and pains of pregnancy or that they had a higher pain threshold based on their exercise. Research has not determined which hypothesis is a more accurate reflection of pregnant women’s experiences. Nonetheless, it is clear that exercising women report feeling better during their pregnancy than their non-exercising peers. Concern has been raised that, with the increase in physical activity, women whom exercise during pregnancy would be more likely to fall or have some trauma to the abdomen which could seriously harm the baby. Research has shown women who exercise are less likely to fall during their pregnancy due to increased flexibility and kinesthetic awareness. Even though fewer falls and abdominal trauma occur with exercise, the American College of Obstetrics and Gynecologists (ACOG) discourages some physical activities due to increased likelihood of abdominal trauma such as skiing, soccer, and skydiving. In general, exercise is known to alleviate stress and this effect remains true also during pregnancy. In addition to reporting less anxiety, women who exercise during pregnancy are more likely to feel less pains and more "in control" of the process of pregnancy.

One aspect of pregnancy that produces anxiety, especially for first time mothers, is the unknown experience of labor and delivery. Some of the potential benefits gained from maternal exercise are seen at labor and delivery. Many mothers who exercise deliver closer to their estimated due date than non-exercisers (Clapp) which can lead to decreases in anxiety of the mothers. Additionally, maternal exercise tends to decrease the total time of labor and delivery, which is often one of the most exciting benefits of maternal exercise, at least to mothers. Maintaining muscle tone logically leads to the ability of mothers to "perform" better during the energy intensive time of delivery. The decrease in time is even more prevalent for multiparous females than first time mothers.

Placental Adaptations

Once it was determined that exercise was not a teratogen to the fetus and the maternal benefits were recognized, many physicians and researchers began to explore what other benefits may occur, such as at the placenta. The placenta is the interface between mother and fetus where oxygen, nutrients, and hormones are transferred to the fetus while waste products are eliminated from the fetus without an intermixing of fetal and maternal blood. The placenta is a unique transient organ that begins developing around day 12 after fertilization, which translates to day 24-26 of the menstrual cycle. This process often begins before the woman knows she is pregnant. Additionally, the placenta is a combination of fetal and uterine (mother's) tissues. The fetal tissue invades the maternal uterus until it encounters the maternal decidual vessels. Once these vessels are penetrated villi begin to form; these are the functional extension of the fetal portion of the placenta to increase surface area for exchange between fetus and mother. Investigation of the effects of exercise on the placental structure has resulted in several findings. First, the jarring and impact from high intensity aerobic activity was not found to have a detrimental affect on fetal growth and development or the placenta. Numerous studies have shown that exercise does not increase spontaneous abortions or placenta complications (placenta previa, PROM, pre-term labor, etc.). Second, if the mother exercises during the period of placentation, or forming of the placenta, there are an increased number of villi which means increased surface area for exchange of nutrients between fetus and mother. Therefore, the infants of exercising mothers receive increased oxygen and nutrients during exercise. This is evidenced in umbilical cord erythropoietin levels, a marker of fetal oxygenation levels, at birth.

Fetal Outcomes

Measuring fetal stress

Of particular focus for researchers in this area is the benefit of maternal exercise to the fetus. Trying to determine if the fetus was stressed in any way during pregnancy proves to be challenging, at best. Some measurements used to determine fetal well-being include fetal heart rate (FHR), fetal breathing, and fetal movements. The most obvious measure of fetal well-being and health is the fetal heart rate (FHR). FHR is the most common and straightforward measure and is a standard measure during pregnancy. So far, research in this area has not found a consistent link between maternal exercise and fetal heart rate. Numerous studies show FHR during maternal exercise usually increases, but some show a decrease (Webb et al. 1994, Clapp et al. 1993, Clapp 1985). It has been hypothesized that some of these differences are due to methodology employed by the studies with FHR being measured before exercise, during exercise, or after exercise in different studies. While the most accurate picture of resting FHR should be before an exercise bout, additional factors need to be considered: time of day, time of mother’s last meal, baby’s gender, and fetal activity state. The process of measuring FHR during exercise is problematic considering the maternal abdomen and limbs move during an exercise bout. These movements cause too much artifact to get accurate EKG or ultrasound recording.

Fetal breathing movements (FBM) are another common measure used to determine if fetal well being has been affected by maternal exercise. During maternal exercise, the findings are usually decreased (Webb et al. 1994). Any differences again can be attributed to different techniques used. However, a major reason for differences, only more recently being investigated, is the effect of the activity state of the fetus on these previous measurements.

Neonatal Outcomes

Post birth measurements also have been examined to determine the relationship between maternal exercise and neonatal outcomes. Some common measurements used to substantiate this claim are Apgar scores, birth weight, and body fat. No differences have been found in Apgar scores between neonates exposed to exercise in utero and those not exposed to exercise. As previously mentioned, neonates exposed to exercise during pregnancy may have lower birth weights due to decreased fat deposition, but they may be of normal weight as well depending on the maternal exercise regime in the last trimester as well as the type of carbohydrates consumed during the pregnancy.

Neonatal and long-term outcomes

Besides the physiological adaptations that occur with the female's body, such as improved heat dissipation, increased villous surface area, and improved cardiac function (Clapp 1993, Clapp 1994, Clapp 1990), some researchers believe adaptations to exercise also take place in the growing fetus. The cardiovascular system, the most well studied system for exercise adaptions, has been the focus of animals and human models regarding the effects of maternal exercise on fetal development. Rodent studies demonstrate that the hearts from offspring of exercised pregnant rats have increased cardiac capillary and muscle fiber density, increased number and viability of cardiac myocytes, decreased diffusion distances, and a slower beating rate (Blake and Hazelwood 1971, Bonner et al. 1978, Parizkova 1975, Parizkova 1979). Clapp et al (Clapp 1985) observed that baseline fetal heart rate during rest was lower in the fetus of an exercising mother. Furthermore, a study shows that fetal HR is lower in fetuses exposed to regular, aerobic maternal exercise throughout gestation relative to those not exposed to maternal exercise (May et al. 2010). Since trends in heart rate (HR) are influenced by neural components in order to accommodate the changing demands upon the cardiovascular system, these changes represent maturation of the autonomic nervous system control and the medulla oblongata (DiPietro 2005).

Current research focuses on the association between intrauterine environment, fetal development, and long-term outcomes of offspring (Barker 2004a, Barker 2004b, Barker 2002, Barker 1994, DiPietro et al. 2000, Wintour et al. 2003). Researchers have studied offspring up to five years after birth to determine long term outcomes of intrauterine environment. Significant associations between maternal physiologic function, fetal heart rate and heart rate at one year have been found (DiPietro et al. 2000). With this in mind, infants born of mothers who exercised during pregnancy had less body fat, improved psychomotor scores and percentiles, and a trend toward earlier ambulation at one year follow-up compared to infants from non-exercising mothers (Clapp 1998). One study looking at five year old children from exercising mothers did better in the areas of general intelligence and oral language, and had better overall score of neurodevelopmental skills than children from non-exercising mothers (Clapp 1996). Considering the findings of recent research, more studies are needed in this area to determine longitudinal effects of maternal physiology on long-term offspring outcomes.

Exercise during Lactation

Since it is now known that exercise during pregnancy is not harmful and there are maternal and placental adaptations as well as potential benefits to the infant, the question has been raised about whether, without further stimulus post birth, the infant will have decreased effects similar to a detraining period of an athlete. However, the mother still has an important influence on the neonate's health via breastfeeding. Breastfeeding represents an extension of the in utero environment. Usually up to about 3 to 6 months the mother is the sole supplier of the baby's nutritional and immunological needs. Again, the question arises how the mother's exercise affects the baby who is now a neonate. Before studying what molecular concentrations within breast milk change in response to exercise, it is imperative to understand what components are normally present in milk and what factors affect their presence and concentration.

There are numerous proteins besides the major and minor whey proteins and alpha-casein and lactalbumin (Koch et al. 1991) such as: galanin, neurotensin (Chen et al. 1999), pro-gamma-melanocortin (Werner et al. 1985 sites Ekman et al. 1985), Leptin (Donnet-Hughes 2000), bombesin and bombesin-like peptides (Koch 1991, Koldovsky et al. 1989, Werner et al. 1985 sites Ekman et al. 1985), delta-sleep-inducing peptide (Koch 1991, Koldovsky et al. 1989- sites Banks, Kastin, and Coy 1983, Horne et al. 2004), motilin (DeClercq et al. 1998), and fibronectin (Fukushima et al 1994). It is known that exercise increases galanin and fibronectin levels in the mother's plasma, while other proteins decrease, For some of the proteins, there is no conclusive evidence about the effects of exercise. For elevated proteins such as galanin and fibronectin, though, it is not known if the breast milk concentration also increases or if is remains unchanged in response to the exercise. It is well established that the GI tract of neonatal mammals is permeable and therefore peptides and proteins can be transported across the intestinal epithelium (Koch et al. 1991 sites Koldovsky 1980; West 1989). How exercise affects protein levels within breast milk is unknown but an area of potentially exciting research.

Breast milk normally includes various hormones such as hypothalamic releasing factors (GHRH, GnRH, TRH), most pituitary hormones (prolactin, oxytocin, melatonin, somatostatin, TSH), thyroid hormones (T3 and T4), some steroid hormones (estrogen, progesterone, corticosteroids) and others (insulin, Calcitonin, and erythropoietin). Many hormones within breast milk are present in concentrations that exceed those in plasma (Polk 1992). Although exercise affects the concentration of these hormones in the maternal plasma, it is not known how these changes affect the concentration within the mother's milk. For example, thyroid hormone levels within the breast milk are primarily determined by maternal circulating triiodothyronine (T3) levels (Oberkotter 1989). Therefore, if maternal thyroid hormones increase, due to exercise, then there will be an increase of this hormone in the breast milk (Amarant et al1982); Koldovsky et al. 1980). Although no research on the affect of these increases to the infant has specifically been done in humans, rodent research has shown that T3 to lactating rats caused increased T3 in serum and milk of mom (Strbak 1984, Michalickova). The increased thyroid hormone in milk caused decreased iodine uptake of thyroid, deceased thyroid hormone secretion, suppressed plasma TSH, causing high plasma T4 which led to accelerated eye opening. These effects caused increased sucrase and maltase activity, and increased activity of liver enzymes (i.e. beta-glycosidases) of the rat pups (Strbak 1984). The low plasma TSH which led to high plasma T4 caused higher growth rate and accelerated overall maturation in rat pups. Since we know that the hypothalamic-pituitary-thyroid axis is mature in the newborn and is activated immediately after birth (Strbak and Michalickova 1984), the infant thyroid gland can respond as an adult thyroid to the presence or absence of hormones in milk.

Some hormones will maintain the same concentration between mother's milk and plasma. Other hormones will be diluted in the milk, and still others will be concentrated in the breast milk. Many growth factors are made de novo at the mammary gland regardless of the maternal plasma concentration of these factors (Polk 1992). It is known that insulin decreases during exercise while glucagon, epinephrine, NE, growth hormones, and cortisol increase. The concentration of growth hormone (GH), or growth related factor (GRF) in breast milk exceed plasma values by several fold. Hence, it has been found in animal research to be concentrated from blood to milk by the mammary gland and was found to reach the stomach of the pups in an intact form (Werner 1986). Purified milk extracts induced the secretion of GH from rat pituitary cells in culture and centrally administered GRF has a stimulatory effect on food intake in rats and a stimulatory effect on digestive enzyme secretion from an exocrine pancreatic preparation. Milk GRF may be involved in regulation of GH secretion from the pituitary of the neonate (Werner et al. 1986) and therefore may benefit the growth of the neonate. Some of the growth factors known to be present in breast milk are: EGF, NGF, TGF, and MGF. Although maternal exercise may increase the presence of growth factors, this may not translate into increased concentration in the breast milk. However, it is not known how exercise affects mammary gland production of these growth factors.

It is known that milk contains cytokines and other immunomodulatory agents and living cells (Savilahti 2005). Breast milk also contains a number of nonspecific anti-infectious substances such as iron-binding lactoferrin, bacteriocide, lysozyme, and the oligosaccharide inhibiting microbial attachment to epithelial cells (Savilahti 2005). Current research has shown that a mother's moderate exercise has no effect on the concentrations of IgA, lactoferrin, or lysozyme in her milk (Lovelady et al. 2003). The affects of exercise on the immune system status of lactating mothers was also determined by measuring: complete blood cell counts, differential leukocyte counts; percentages and absolute counts of peripheral lymphocyte cells (CD3+, CD3+CD8+, CD3+CD4+, CD19+, CD56+); neutrophil killing and oxidative burst activity; and in vitro mitogenic responsiveness of lymphocytes. The exercise during lactation had no affect on immune status compared to matched sedentary lactating mothers (Lovelady et al. 2004).

Since lactation is a continuation of the female body supplying the needs of a new quickly growing infant, it is important to understand the effects of exercise on breast milk composition. The presence of biologically active peptides, hormones, growth and immune factors in milk is evident. The notion that these factors have a physiological role in the development of the newborn is strongly supported by research. However, there is still much that needs to be learned. This is an area of where more research needs to be done.

Exercise in the lactation period offers benefits to the mother as well. Of course, breastfeeding allows for bonding between mother and child as well as nutrient exchange, but breastfeeding is a selfless act by the new mother that requires physical, mental, nutritional, and energy stores focused on her new baby. Especially for first time mothers, this bonding experience is a blend of bliss and anxiety. Exercise during this period allows a new mother a sense of taking care of herself and improves recovery to pre-pregnancy weight, and helps to balance the emotions during this difficult time of transition.

Types of Physical Activities

Since women have their own preferences and dislikes, there are a variety of physical activities that they like to participate in during pregnancy. Thus far, research has been done on most of these types of physical activities ranging from aerobic to weight lifting types. In general, most types of aerobic activity are safe to perform during an uncomplicated healthy pregnancy. From low impact aerobic walking to high impact aerobic running, all of these physical activities are safe IF there are not complications or symptoms during the pregnancy. Some activities will need to be modified to keep both the mother and fetus safe. For example, instead of bicycling outside on a trail, a pregnant mother can exercise on a stationary bicycle to avoid an accident. Even weight training and abdominal exercises are acceptable during pregnancy. Again, some physical activities should be modified to keep the pregnancy safe. For example, instead of free weights for resistance, a pregnant female can use weight machines, which control the range of motion and the weights. Abdominal exercises are important since these muscles will be necessary during delivery, but after six months a pregnant mother cannot lay on her back. During pregnancy, a mother needs to do crunches either upright or at an angle rather than flat on her back, to prevent compression of the vessels. All contact types of physical activities or physical activities that have the potential for abdominal trauma are to be avoided during pregnancy, such as soccer, football, racquetball, skydiving, etc. For a complete list of acceptable activities and when to discontinue safe activities please see the American College of Obstetrics and Gynecologists (ACOG) website.

Application

What does this mean for pregnant women? If a woman was active prior to becoming pregnant then she can continue activity during the pregnancy, as long as the pregnancy progresses normally and without complications. If there are complications that arise during the pregnancy, then a woman should discuss with her OB/Gyn physician the possibility of maintaining physical activity throughout the pregnancy. If a woman was not active prior to becoming pregnant then she can still exercise during pregnancy. However, she must start out slowly and lightly and should do so under the supervision of a trained professional. Regardless, of whether a woman was active prior to pregnancy or not the exercise should be self limiting and pain free.

What does this mean for people working with pregnant women? Let the woman set her own limitations and boundaries, with reason. For the most, the pregnant mother knows what her limitations are from her exercise regime, therefore, she should know what she can and cannot do. Although, woman do like for people to dote on them during this wonderful time of their life, it is important to remember to treat her as a fully capable individual. The pregnancy does not make her incapable of doing everyday tasks; so people should treat her as they always have. Women are strongly encouraged to discuss exercise during pregnancy with their Ob/Gyn physicians and to follow the ACOG recommendations.

CONCLUSION

Myriad research studies have reiterated that exercise during pregnancy is not harmful to the fetus or its development. Additionally, this exercise has various positive adaptations for the mother, such as less weight gain. If exercise occurs early enough to influence placentation, then beneficial changes occur to increase villous surface area. The potential benefits a fetus receives from exercise exposure in utero is a growing area of research, especially as it relates to programming later in life. Although lactation represents a continuation of the in utero environment, as far as the mother supplying all of the neonate’s needs, there is relatively little research looking at the affects of exercise on breast milk composition. Overall, exercise is beneficial at any age and stage of a female’s life and may benefit the baby as well.

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In: Physical Fitness: Training, Effects and… ISBN: 978-1-61728-672-8
Editors: Mark A. Powell

Chapter 8

THE HEALTH BENEFITS OF AEROBIC ACTIVITY AND PHYSICAL FITNESS IN YOUNG PEOPLE♦

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ABSTRACT

Results from studies involving adult participants have definitively established that physical activity and cardiorespiratory fitness are inversely correlated to morbidity and mortality. The evidence of the health benefits for physically active and fit adults is well known. There is

♦ A version of this chapter was also published in *Aerobic Exercise and Athletic Performance: Types, Duration and Health Benefits*, edited by David C. Lieberman published by Nova Science Publishers, Inc. It was submitted for appropriate modifications in an effort to encourage wider dissemination of research.

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a wealth of data which has shown that physically active and fit adults can help attenuate the effects of hypertension, insulin resistance, hyperlipidemia, obesity and cancer. However, the relationship between activity, fitness and the health benefits during childhood are less well established. Although it is intuitive to propose that an active child will become an active adult, the research evidence is weak. Similarly, the extent to which children's fitness and activity must decrease to seriously compromise their current or future health is also unknown. There is however growing concern for the future health status of children due to the increased levels of overweight and obese children and increased reporting of cardiovascular risk factors. Prospective data is needed to elucidate the complexity of these relationships. This complexity is partially due to problems related to 1) methodology i.e. how do we measure activity and health outcomes precisely; 2) biology i.e. children are growing and maturing at different rates and 3) sociology i.e. the effects of the environment. These problems therefore pose real challenges for policy makers as to whether they should concentrate resources on those child individuals who are deemed 'at risk' i.e. low fitness and low physical activity patterns or to focus across the whole child population. This review will explore the relationships between physical fitness, activity and health in young people as well as describing the evidence for health benefits in this age group. The review will also discuss the implications for strategies of health related physical activity promotion at local and national levels.

I. The Relationship between Activity, Health and Fitness in Young People

Over the last twenty years there have been comprehensive reviews about the measurement and assessment procedures used to define the physical activity patterns of young people and adults (Corder and Ekelund, 2008). Although there is no one gold standard for the measurement of physical activity, the various pedometers, accelerometers, heart rate monitors, indirect calorimetry, double labelled water, direct observation and questionnaire methods have broadly found similar results. That is, boys are more active than girls, activity declines with age and the relationship between fitness and activity becomes stronger the older the participant. The latter finding is important because it has yet to be conclusively shown that physical activity is a strong predictor for fitness in young people as it is in adults. When the two measureable outcomes of activity and fitness in adults are linked to morbidity and mortality, the link is even stronger. In young people, there is as yet no consensus. The associations between health, activity and fitness are important to understand in order for them to be translated into policy, thus ensuring meaningful enhancements in health throughout childhood, adolescence and adulthood. The declining levels of physical activity, not only in adults but also young people, are a major concern world wide. The increasing incidence of life-style related chronic diseases (previously called hypokinetic diseases) once associated only with adults are now being observed in young people e.g. the increasing incidences of overweight and obesity. Researchers had considered that children have not yet lived long enough before major health problems occurred due to a lack of activity, but now there is empirical evidence that children and adolescents' health is suffering (Viner and Barker, 2005).

I.1. Definitions of Physical Activity, Health and Fitness

There is common agreement that physical activity is a behaviour and therefore subject to a multitude of extraneous factors (Casperson *et al.*, 1985). Although physical activity can be described as any bodily movement produced by the skeletal muscles resulting in energy expenditure, knowing the context for how and when young people move is important. It is likely that researchers have underestimated how complex activity is. Activity is both context and task specific e.g. type, duration and frequency of activity, as well as, whether the activity is performed habitually as part of one's work or recreationally. In children, the activity behaviour is confounded by the growth, maturation and development of the young person. Participation in activity is influenced by peer group behaviour, the increasing levels of independence with age and/or the increasing availability of monies to engage in different activities.

Physical fitness is defined as an attribute and has usually been referred to in the context of physical work. This is largely as a consequence of research work in the 19th and 20th century which quantified how much physical work labourers could perform during set jobs. Therefore, fitness was related to performance, although within the last 30 years there has been a broader move to incorporate fitness to health outcomes. Fitness is generally sub-divided into endurance or cardiovascular fitness (often described as aerobic), strength, speed, power and flexibility. From a performance perspective and depending on the relative importance of these sub-divisions to a particular sport, they can be easily measured. From an adult health perspective, there is more empirical evidence for cardiovascular fitness, strength and flexibility compared to speed and power. However, in young people, there is still too little information to describe the associations between fitness and health. This is mainly because fitness has a large genetic component to it and although it can be improved through training; there are too few training studies which have focused on health outcomes in children and adolescents.

Fitness training for health has not been extensively studied in young people possibly due to the fact that mortality rates in developed countries have shown a downward trend and therefore, the emphasis on this attribute is not a priority. However, in terms of morbidity many countries are showing adverse trends or maintenance of high levels related to obesity, smoking, asthma, diabetes, sexually transmitted diseases and pregnancy (Newacheck and Taylor, 1992). Particularly in the case of overweightness and obesity the gradual process of the disease has, until now, distracted professionals' attention away from the problem. Now most countries around the world have developed strategies to combat the spread of these lifestyle diseases (WHO, 1995; Health Education Authority, 1996; Dept of Health, 2004).

I.2. Physical Activity Guidelines and Young People

The first set of recommendations for physical activity guidelines were produced by the American College of Sports Medicine in 1988. Although the recommendations were based on adult guidelines, it was proposed that children should engage in at least 20 minutes of vigorous physical activity each day. A more considered approach was taken by an International Conference on Physical Activity Guidelines for Adolescents who in 1993 also attempted to base guidelines on empirical evidence (Sallis and Patrick, 1994). The consensus of the panel was that adolescents should;

1. be active on a daily basis, whether it be through work, play, physical education, sport, or active transport.
2. engage in at least 20 min of sustained moderate to vigorous activity at least three times a week.

In 1997, the Health Education Authority (England) convened a meeting to produce guidelines for activity in children (Biddle *et al.*, 1998). Again systematic reviews were conducted and attempts to base the recommendations on empirical evidence were conducted. The recommendations proposed that;

1. currently active children should achieve a minimum of 60 min of moderate activity per day, whereas less active children should strive for at least 30 min of moderate activity
2. children should also engage at least twice per week in activities designed to promote bone growth, flexibility, and strength.

One of the differences between the first two sets of American recommendations to those from England was that the Health Education Authority panel attempted to take into account individual differences (Pate *et al.*, 1998). A distinction was made between those children who were already active and those who were least active. In 2004, these recommendations were re-affirmed by the Chief Medical Officer's report on physical activity and health (Department of Health, 2004). These guidelines have since been further reviewed by researchers in the United States who concluded that school children should engage in at least 1 hour of moderate to vigorous activity per day and that activities should be enjoyable and developmentally suitable.

Recent evidence from the European Youth Heart Study has however questioned the evidence base for these guidelines and suggested these are not robust enough (Bo Andersen *et al.*, 2006). They randomly selected 1732 children aged between 9 and 15 years old across Denmark, Estonia and Portugal, risk factors such as systolic blood pressure, triglyceride, insulin resistance, skinfolds amongst others were collected. Their study found a graded negative relationship between clustering of the risk factors and physical activity. This risk was raised in the first three quintiles compared to the most active quintile. It was proposed that the current guidelines of at least 1 hour could be an underestimation of the activity necessary to prevent clustering. Their conclusion was that achieving 90 minutes of daily physical activity might be necessary to prevent insulin resistance and the clustering within cardiovascular disease risk factors. As to which guidelines are the most appropriate is debatable. It is important to emphasise, as it is often mis-quoted in the media that all the recommendations are only *guidelines*. All the members of the panels have struggled to interpret the data on activity and fitness of children and the impact on health, as well as predicting the impact on future adult health. All the panels have, in order to produce recommendations that can be understood by the general public, had to over simplify and treat physical activity as a one dimensional phenomenon. It is therefore unsurprising, given the social, physiological, psychological, environmental and temporal factors which influence activity, that researchers are no closer to precisely defining physical activity recommendations. Whether there are *optimal* levels of physical activity is debatable and might result in a search by future investigators for the “holy grail” of recommendations. Currently, the physical activity guidelines in both America and the United Kingdom are being revised.

I. 3. The Adult-Child Relationships between Physical Activity, Health and Fitness

Blair *et al.* (1989) produced a flow diagram which highlighted the inter-links between:

1. childhood activity and childhood,
2. childhood activity to adult health,
3. childhood activity to adult activity,
4. adult activity and adult health,
5. childhood health to adult health.

Whilst this diagram simplistically represents the proposed relationships between activity, health and age, it has provided a model to investigate and rationalise why childhood activity is beneficial. The rationale for ensuring a physically active childhood includes sociological, psychological and physiological enhancement from activity which has a direct impact on childhood health. Secondly, a strategy of reducing the impact of health risks e.g. avoiding becoming overweight as a child and the direct impact on a healthy lifestyle as an adult. And thirdly, the intuitive proposition that an active child is more likely to develop into an active adult.

From the bullet points 1-3 in the above list by Blair and colleagues, it is still yet to be conclusively established that positive associations in childhood activity will impact either on child or adult health. By far the strongest evidence is for the relationship between adult activity and adult fitness (see point #4 above). Both fitness and activity are strongly and independently associated with health in adults, whilst the relationships are weaker in children. The strong and inverse relationship between activity and fitness, particularly cardiovascular, in adults is such that inactivity (sedentary activity) is prevalent and carries a risk as high as other risk factors e.g., smoking (Leon *et al.*, 1987). Therefore, one of the strategies that organisations and Governments must focus on is to decrease the amount of sedentary behaviour.

So far in this review, the focus has been on increasing physical activity but the reverse of this scenario is decreasing the amount of sedentary behaviour. It is important to note that they are not one and the same. The reasons for being active or being sedentary will of course be complex, but they are very different concepts. Therefore, many researchers over the last 10 years have focused their attention on decreasing the amount of sedentary behaviour exhibited by children. Research has invariably focused on television watching and computer playing and although this subject is beyond the scope of this review, readers are referred to a review by Marshall *et al.* (2006).

I.4. Physical Activity, Health and Fitness of Children

Activity is important for the development of children's physical and mental well being, and this fact is well accepted. As previously discussed the problem is how much activity is best for the growing child. Although this might be difficult to ascertain for a child who is healthy, who engages in sport or other leisure activities, the answers might be more forthcoming if we examine children who are not active. This inactivity could be either through choice or because they have a medical condition which prevents them being active. Researchers are therefore concerned about declining activity levels particularly in the adolescent years and the potential impact on future health. Early work by the Children's Health and Exercise Research at the University of Exeter examining activity, fitness and health and found that children did possess a range of cardiovascular risk factors e.g. high blood pressure, cigarette smoking or were overweight (Armstrong *et al.*, 1991). However, they concluded that the relationships between activity and fitness were weak and that there was not enough longitudinal evidence to show a connection between child health and future adult health. However, there have now been a number of publications which suggest stronger associations between being active and possessing a more favourable weight status or healthier cardiovascular disease profile (Brage et al., 2004; Andersen *et al.*, 2006; Ness *et al.*, 2007).

One of the main difficulties is that the common measure of health is 'mortality' which cannot be appropriately used in child studies. The other measure of health, 'morbidity' can be used with such outcomes as raised blood pressure, lipid profiles or fatness being recorded. But even these factors will only account for a certain percentage of the eventual cardiovascular mortality. A more immediate problem is the issue of increasing fatness in children and where there is a very strong relationship between cardiovascular fitness and fatness (Boreham *et al.*, 1997; Winsley *et al.*, 2006). It is important to highlight that the cardiovascular fitness of the overweight or obese child is compromised by the amount of fatness *per se*, not because the cardiovascular fitness of the child is deficient. When appropriately scaled for body fatness, overweight and normal weight children have similar aerobic fitness.

Therefore, whilst relationships between activity, fitness and health in adults are stronger than children and adolescents, it is intuitive to try to instil an active lifestyle in our young people. Data which tracks activity in childhood through to adolescence and into adulthood has shown a weak to moderate relationship (Malina, 2001). However, just because it is a weak relationship does not make it unimportant. Given the complexity of the relationships and confounding variables such as the environment, impact of work and family, times when ill, the relationship might only ever be weak or moderate. This observation should not detract from practitioners advocating physical activity as a preventative strategy to ill health throughout the life cycle.

I.5. Hypoactivity/Deconditioning due to Illness - Asthma and Obesity

Hypoactivity is defined as an activity level which is lower than that of healthy peers of similar age, gender, cultural and socioeconomic background. Childhood diseases can both be a direct and indirect cause of hypoactivity. For example, a child with severe arthritis or muscular dystrophy is very limited in their movement patterns because of the disease. Conversely, a child with mild asthma can be active but often is not, but the hypoactivity might be co-incidental to the disease. There are many reasons why the disease might lead to a state of hypoactivity other than the actual disease restricting movement. These include over protection by parents or carers, fear of the consequence of performing activity, social isolation and ignorance about the effects of activity. All these factors including the progression of the diseases lead to a ‘detraining effect’ and functional deterioration. In particular functions which decline include; the maximal oxygen uptake (a measure of aerobic fitness), the elevation of the metabolic cost of submaximal tasks and the increased perception of effort in performing the tasks, and the reduction in strength, anaerobic power, and flexibility.

Physical activity recommendations for children with chronic diseases are uncommon, for some some of the reasons outlined above in healthy children, i.e. the complexity of the relationships between fitness, activity and how the processes evolve over time. In the case of children with chronic diseases there is the added issue of understanding the pathology of the disease and how physical activity may or may not affect the condition of the disease. In very few cases activity will affect the pathology of the disease, an exception is obesity or perhaps type 2 diabetes when insulin resistance is decreased. In other cases, activity may only be used to retard the disease process. For example, in cystic fibrosis it has been shown that the higher the aerobic fitness of the child, the longer the survival rate of the individual will be. Therefore, exercise is used as one therapy to increase length of life. In Duchenne muscular dystrophy, the use of exercise is controversial with some advocates suggesting exercise can do more damage to the muscle proteins, whilst others argue if strength can be improved, the increased mobility can have a significant impact on quality of life. Two particular diseases for which there is a growing amount of information about the relationship between fitness and activity is asthma and obesity and these will be reviewed in the next section.

II. Fitness and Physical Activity in Children with Diseases

II.1. Children with Asthma

II.1.1. Background

Asthma is a very common chronic disease involving the respiratory system in which the airways constrict and become inflamed. Airway obstruction is reversible either spontaneously or with treatment. One characteristic of asthma is that the bronchial system is hyper-responsive to a variety of triggers. These stimuli include airway infections, exposure to allergens or air pollutants, inhalation of dry and cold air, and exercise if it is of a sufficient intensity and duration. A considerable proportion of asthmatic children are affected by exercise-induced asthma (EIA), with the prevalence believed to be around 90 % (Wilkerson, 1998). In most patients, EIA leads to coughing, wheezing and shortness of breath in a short period after exercise

(Storms 1999). Some patients complain about chest discomfort, nausea and stomach ache after exercise. In children, symptoms usually resolve within 10-90 min after the cessation of exercise. The purpose of the following sections will be to discuss the relationship between asthma and exercise when dealing with an active paediatric population to establish whether significant differences exist in the levels of habitual physical activity and aerobic fitness.

II.1.2. Asthma and physical activity

Although having a diagnosis of asthma or EIA does not necessarily prevent participation in sporting activities, there is a common perception that asthmatic children have a reduced capacity for exercise. In other words, it is perceived that asthmatic children, particularly those with EIA are not as physically active as their non-asthmatic counterparts. Despite the amount of speculation, only a limited number of studies have assessed the physical activity levels of asthmatic children and the results of these were highly controversial. These discrepancies are mostly associated with the difficulty of measuring with a high reliability, the habitual levels of physical activity by questionnaire, particularly in children (Kowalski *et al.*, 1997). For instance, Nystad (1997) administered the ISAAC (International Study of Asthma and Allergies in Childhood) questionnaire (Asher *et al.*, 1995) to 4021 school children living in three different areas of Norway and showed no difference in the physical activity levels between asthmatic and non-asthmatic children. Furthermore, the authors showed no difference in the exercise frequency and the number of hours spent exercising per week between the two groups. In the same way, using the 7-day recall Physical Activity Questionnaire for Children (PAQ-C) (Crocker *et al.*, 1997), Welsh *et al.* (2002) reported no differences in the physical activity levels of 28 asthmatic children and 200 non-asthmatic children. Conversely, Weston *et al.* (1989) found that asthmatic children were more frequently active than their non-asthmatic counterparts as measured by a self-administered questionnaire. Although asthmatic children were found to experience higher degrees of anxiety prior to exercise, they were characterized by higher school and daily physical activity levels.

In summary, these data suggest that asthmatic children have comparable physical activity levels compared to their non-asthmatic counterparts. However, in order to make definitive conclusions about this issue, further studies need to be carried out using more accurate recording systems of habitual physical activity and daily energy expenditure (e.g. accelerometry associated with or without heart rate recordings) rather than questionnaires.

II.1.3. Asthma and aerobic fitness

It also remains unclear whether significant differences exist in the aerobic fitness between asthmatic children and their non-asthmatic counterparts. Whilst some studies reported no difference in the aerobic fitness levels between asthmatic and non-asthmatic children and adolescents (Hedlin *et al.*, 1986; Fink *et al.*, 1993; Santuz *et al.*, 1997; Boas *et al.*, 1998), others demonstrated reduced aerobic fitness in asthmatic children. For instance, Boas et al. (1998) found similar values of VO_2max in 22 asthmatic children and adolescents and 22 age-matched non-asthmatic controls. Likewise, Fink *et al.* (1993) found no differences in VO_2max values between active and inactive groups of stable asthmatic and non-asthmatic children. On the contrary, Varray *et al.* (1989) found that 11 asthmatic children had significantly lower VO_2max values when compared with 11 non-asthmatic children matched for age, sex, height and weight. Similarly, Counil *et al.* (1997) reported reduced VO_2max values of around 10 % in 19 asthmatic boys when compared to 14 non-asthmatic boys of the same age. Despite these controversies, it has been suggested that the reduced aerobic fitness of any asthmatic child is associated with their sedentary lifestyle and that endurance training can enhance their aerobic fitness to be comparable to that found in non-asthmatic children (Fink *et al.*, 1993). According to some authors, asthmatic children are able to achieve similar levels of aerobic fitness as long as their physical activity levels are comparable with those of normal children (Santuz *et al.*, 1997). However, it is worth noting that in general, the benefits of increased physical activity are more pronounced in children and adolescents with severe disease compared to those with only moderately severe asthma (Hebestreit, 2008).

II.1.4. Recommendations

Children with asthma can exercise safely. Additionally, they can successfully participate in competitive sports at a very high level. However, a number of principles need to be adopted to minimize exercise-related risks (Hebestreit, 2008). Firstly, children with asthma should select the least asthmogenic activities. For instance, asthmatic children should be encouraged to practise swimming rather than land-based activities since EIA is less common. However, this recommendation does not apply to those few patients who experience bronchial constriction when swimming in chlorinated water. Also, it is well known that inhaling cold and dry air whilst exercising increases the risk of a severe bronchial obstruction. Therefore, asthmatic children are sometimes advised not to participate in winter sport activities. If children with asthma are led to practise skiing in dry air and cold temperature conditions, it is advised to wear a face mask to prevent the loss of heat and water from the bronchial system (Silvers *et al.*, 1994). Asthmatic children also have to be especially careful if exercise is performed in an environment with a high level of dust or ozone and a high concentration of allergens in the air (Mussaffi *et al.*, 1986). Furthermore, children should not exercise during a period of severely reduced airway patency. It is also worth noting that the warm-up is crucial before exercise to lower the risk for EIA during the subsequent 2 hours (Reiff *et al.*, 1989). However, the optimal pattern of the warm-up should be determined individually. Finally, children with asthma should inhale anti-inflammatory drugs (e.g. β_2-adrenergic agonists as salbutamol) 10-20 min before exercise and even during exercise in case of EIA (Hebestreit, 2008).

II.2. Obese Children

II.2.1. Background

Since the 1970s, the childhood obesity rate in the United States has more than doubled for children aged 2-5 years and adolescents aged 12-19 years, and it has more than tripled for children aged 6-11 years (Institute of US Medicine Web site, 2004). As a result, children are at increased risk of acute and chronic medical problems, which are associated with increased morbidity and mortality. These associated problems include insulin resistance, type 2 diabetes mellitus, coronary artery disease, hypertension, stroke and heart failure (Eckel and Krauss, 1998). The evidence of the increasing prevalence of obesity during childhood is particularly alarming since it has been assessed that 80 % of obese adolescents become obese adults (Schonfeld-Warden and Warden, 1997). The causes of obesity in children and adolescents are multiple and are continuously being debated. However, the increase of body fatness during childhood and adolescence has been associated with a decline in reported time for exercise (Watts *et al.*, 2005). The purpose of the following sections will be to discuss whether body fatness and aerobic fitness are associated or considered as independent risk factors for health. The aim is to ascertain whether significant differences exist in the aerobic fitness between obese and normal-weight children. Furthermore, it is also considered as to whether aerobic exercise training alone has a beneficial effect on body composition, blood profile and aerobic fitness in overweight and obese children.

II.2.2. Obesity and aerobic fitness

Confusion exists on the proper expression of VO_2max data when comparing obese and normal weight individuals. According to Goran *et al.* (2000), VO_2max should be expressed per unit of fat-free mass ($mL \cdot kg\ FFM^{-1} \cdot min^{-1}$) when comparing the physiological ability of the tissue to maximally consume oxygen, since FFM is more metabolically active than fat mass (FM). Conversely, when looking at endurance performance or the ability to perform a submaximal aerobic exercise, oxygen consumption relative to body mass should be used. Comparisons in VO_2max values relative to body mass appear to be clear, with numerous studies reporting a significantly reduced VO_2max in obese children compared with normal-weight children (Epstein *et al.*, 1983; DeMeersman *et al.*, 1985; Zanconato *et al.*, 1989; Rowland TW, 1991; Maffeis *et al.*, 1994; Goran *et al.*, 2000). This is certainly attributed to the overcorrection related to the excess of body fatness in obese individuals. However, when scaling for FFM, VO_2max data were found to be similar between obese and normal-weight children (Cooper *et al.*, 1990; Maffeis *et al.*, 1993; Maffeis *et al.*, 1994; Treuth *et al.*, 1998; Goran *et al.*, 2000). These findings support the proposition that the maximal oxygen consumption of fat-free tissue is independent of the body fatness rate and the limiting factor in aerobic-type activities for the obese individual is not the cardio-respiratory system. Some studies showed that it was physiologically more difficult for the obese individuals to do the same amount of work as normal weight individuals, at least in weight-bearing activities (Mattsson *et al.*, 1997; Goran *et al.*, 2000). For instance, Mattsson *et al.* (1997) reported that obese women used 57 % of VO_2max during normal walking, whereas their normal weight counterparts used only 36 % of VO_2max. In the same way, Goran *et al.* (2000) found that heavier individuals required a greater percentage of VO_2max than normal weight subjects to complete the same running task (44 vs 37 % in children, respectively; 44 vs 36 % in adults, respectively). Their finding was associated with a higher submaximal heart rate, a higher respiratory exchange ratio and shorter time to exhaustion in obese individuals. Therefore, obese individuals were found to be limited in their ability to perform sub-maximal aerobic exercises.

In summary, obese children do not have lower maximal aerobic power of their fat-free mass compared with their lean counterparts or impaired cardio-respiratory and pulmonary responses to exercise. On the contrary, the overweight and obese children require a greater proportion of their aerobic capacity to perform weight-bearing physical activities. Therefore, children with obesity are likely to fatigue more quickly during submaximal exercise, which requires the mobilisation of their increased body mass.

II.2.3. Exercise training, body composition, blood profile and aerobic fitness

The majority of studies that controlled exercise training independently of dietary modification on body composition, blood profile and aerobic fitness showed beneficial effects in childhood and adolescent obesity. For instance, after a 1-year exercise intervention, Hayashi *et al.* (1987) demonstrated a decrease in bodyweight and resting heart rate and an increase in left ventricular end-diastolic dimension in obese children aged 10-11 years. Conversely, the normal-weight control group who participated in their regular physical education classes gained weight and no changes in their cardiac dimensions over the year. Furthermore, Gutin *et al.* (1997) found in 35 obese children aged 7-11 years that a 4-month programme involving 40 min of aerobic exercise 5 days per week resulted in decreased levels of body fat (-4.1 %) and an enhanced cardiac autonomic function by a decreased ratio of sympathetic to parasympathetic activity. The same intervention programme also resulted in a decreased subcutaneous abdominal tissue (-16.1 %) and less accumulation of visceral adipose tissue in 74 obese children compared with a non-exercise control group (Owens *et al.*, 1999). It is also worth noting that the 4 months of aerobic exercise training in the absence of changes in diet, decreased the levels of fasting plasma insulin and leptin in association with decreased plasma triglyceride levels (-0.24 $mmol \cdot L^{-1}$), suggesting that exercise training may improve glycaemic control and decrease the insulin resistance syndrome in obese children (Ferguson *et al.*, 1999; Gutin *et al.*, 1999). However, those benefits were lost when obese children became less active (Ferguson *et al.*, 1999; Gutin *et al.*, 1999).

In summary, the well controlled studies that examined the effects of exercise training alone on body composition and the detrimental metabolic consequences of childhood and adolescent obesity were small. However, the studies discussed above suggest that exercise training beneficially modifies body composition without changes in bodyweight and body mass index. Furthermore, exercise training is associated with increases in cardiovascular fitness in obese children. However, whilst exercise training is not always associated with large changes on blood lipid profile and glycaemic control, diet may be a more important determinant in obese young people (Watts *et al.*, 2005).

II.2.4. Recommendations

Many studies have failed to provide adequate information regarding important elements of the exercise prescription such as intensity. On the basis of the studies cited above, children should regularly participate 5 days per week in 40 min or more of moderate to vigorous physical activity. Furthermore, it is advised obese children practise low intensity non-weight bearing activities like bike riding and swimming, as these may result in greater ease of performing the physical tasks, resulting in greater energy expenditure and weight loss. Also, the physical activity sessions should be supervised by a qualified exercise leader.

III. PROMOTION OF HEALTH, PHYSICAL ACTIVITY AND FITNESS SCHEMES – POLICY AND PRACTICE

III.1. Environmental Factors

In 2008, NICE (National Institute for Health and Clinical Excellence) a National Health Service organisation (NHS) in the U.K. issued guidelines on promoting and creating built or natural environments to promote physical activity. A specific guideline was the need for environmental factors to be implemented thus making it as easy as possible for people to be habitually active. The guidelines which could be applied to children and adolescents included:

- Ensuring planning applications for new developments always prioritise the need for people to be physically active as a routine part of their daily lives.
- Ensuring pedestrians, cyclists and other modes of physically active transport are given the highest priority when developing or maintaining streets and roads.
- Ensuring new workplaces are linked to walking and cycling networks.

Whilst past environmental interventions such as legislating for treating waste products and enhancing and maintaining food and water quality have been success stories, this cannot be stated for cases of environmental interventions and physical activity (Sallis *et al.*, 1998). This lack of success may be due to the difficulty of not being able to separate the different social, personal and cultural factors from the environmental impact thereby showing a direct effect due to the environmental changes. Models of ecological theory of physical activity such as the one proposed by Sallis and Owen (1996) accounts not only for the specific environment in which the physical activity takes place, but the social and cultural context, as well as, the "behaviour setting". For example, sports fields and gymnasia in schools have both a physical and social setting that are designed to promote physical activity in schools. This example is also the consequence of a public policy because the various school laws, in different countries, specify the amount of physical education and curriculum time children should engage in physical activity. In the context of the behaviour setting, some children will engage more actively in the lesson than others and therefore might benefit to a greater extent. The above scenario is a very direct example, mainly because the activity i.e. the P.E. lesson is enshrined in law, but there are also other environmental examples that can affect physical activity. For example, in many westernised countries, one strategy has been to try to increase the number of children that walk or bike to school. This has meant important co-operation is needed between parents, the school and the local authority to ensure such resources as a safe route maps to school, organising bike and walk days to school and/or walking bus schemes, as well as having available better road signage and cycle paths to schools.

More recently, another theoretical model known as the Environmental Research framework for weight gain prevention (EnRG) has been proposed (Kremers *et al.*, 2006). This framework encompasses social, psychological and ecological models of health behaviour to investigate obesogenic (low physical activity and excessive energy intake) environments. A range of mediating factors such as personality, sedentary behaviour, active transport, attitude, self-efficacy and intentions are all considered in an attempt to explain the outcomes on physical activity and energy intake. Clearly, the more detailed the models become, the more complex are the data sets and therefore, the more difficult is the interpretation. However, it is vitally important that investigators develop and adapt these models theoretically from the empirical evidence, in order to prioritise what are the key determinants.

Environmental interventions to increase physical activity in children need to be based on empirical findings, a theoretical framework and as important, be practical. Unfortunately, research literature is sparse and cannot at present evaluate the influence and impact of the environment. Past health promotions have focused on altering attitudes to activity, the determinants of activity e.g. accessibility or cost and the environment e.g. open spaces to promote activity or decrease sedentary behaviour. However, more research is needed in this area.

III.2. School Factors

The promotion of enhanced physical activity through additional physical education has been a favoured intervention strategy in many countries. The opportunity for a ‘captive’ audience in which to deliver the physical activity message is clearly an opportunity that cannot be missed. Coupled with the fact that children attend school from an early age provides a setting that affects positive behaviours. Although rigorously controlled studies of physical activity intervention studies are sparse, results have been positive. Most outcomes have tended to focus on knowledge of health, physical fitness tests and attitudes to activity. However, it should be noted that studies tend to be short in duration, with little opportunity for follow up evaluations. Not all researchers are convinced that better facilities or increased time allocated to PE will improve activity levels in children and will impact on the rising epidemic of obesity (Metcalf *et al.*, 2004).

However, given the multi-dimensional aspects of health, promoting early life experiences through physical activity is considered an important strategy to foster good habits. Primary school age (typically 5-11 years) is often a time when movement skills, co-operative games are emphasised rather than competitive games and the intensity of these activities has been criticised as being too low to enhance health (Mota, 1994). But, the development of foundational skills and competencies and making the first experiences of activity to be fun and inclusive probably takes precedence. Perhaps the impact of the enhancement of health via the intensity of activity becomes more important during their secondary school years (typically 11-16 years). However, it is also a time when it is known that physical activity patterns decline dramatically, particularly in girls (Armstrong and Van Mechelen, 1998). Therefore, we would advocate a strong focus of research attention on the adolescent years to understand why these patterns change and how the declining patterns can be reversed or slowed. The adolescent period is also a period, particularly in the U.K. when physical activity through the national curriculum of P.E and games varies considerably between schools. The national recommended amount is 8-10 % of total curriculum time but few schools meet this target. Although the U.K. Government has targeted fours hours of PE for the future, it is unclear if this target will be met. Interestingly, those studies which have examined academic performance and increased physical activity have not found a negative impact on academic performance. Although the empirical evidence is limited and definitive conclusions incomplete, there is scope in this area to show school head teachers that increased physical activity can have additional benefits besides health ones e.g., improvement in cognition, academic test scores, attention in class, absenteeism and behaviour (Dwyer *et al.*, 1983; Sallis *et al.*, 1999; Coe *et al.*, 2006; Ahamed *et al.*, 2007).

Strategies to either objectively measure or enhance the frequency of physical activity in schools are common across the developed world. These include the 'JUMP-in' programme in Amsterdam, Holland (Jurg *et al.*, 2006), the National Health and Nutrition Examination Survey (2003-04) in the U.S., the health-related fitness and later health-related physical activity P.E. curriculum in England during the late 1980s and early 1990s and project SHAPE in Australia (Dwyer *et al.*, 1983). Despite these resources and considerable attention from programmes world wide, there is still an urgent need for action on children's health within a school setting. However, schools must not be considered as a panacea to society's problems of worsening health issues for children and adolescents. As much as physical activity is multi-dimensional, so too must the problem be tackled from numerous other organisations. This includes political intervention.

III.3. Local and National Government Policies

In their review Sallis and colleagues (1998) emphasised the importance of inter-agency advocacy, coordination and planning. Using a model developed through the New South Wales (Australia) Physical Activity Task Force (1997), agencies from the police, criminal justice, community organisations were identified to work together. Transportation departments were also involved to assist in urban planning, public transport and cycling paths. In the U.K. the guidance by NICE encourages local authorities, transport, planning and development professionals to work together on making towns and cities more liveable by advocating a healthy lifestyle through increased physical activity. Other groups including the media and education services were also identified as important agents in affecting change. It is clear that this level of co-ordination is needed to have the maximum effect of increasing physical activity levels not just in children, but also adults.

In the U.S. a National Coalition to Promote Physical Activity (NCPPA) was formed in 1995. Bringing together many of the key medical, sports and educational organisations to promote physical activity, NCPPA models itself on the coalition that has had such success on combating tobacco use in the U.S. One of the key strategies of the NCPPA has been to work with legislative bodies at both national and state levels. These types of strategies are being replicated from country to country such that levels of involvement and co-operation between the different organisations have increased. For a review see the work of Blair and colleagues (1996). As yet however, there appears to be little evaluation from which to conclude their effectiveness (Kremers *et al.*, 2008).

IV. Summary and Conclusion

There is a logical rationale for promoting physical activity in children and adolescents, despite the current evidence being weak to moderate with regards to its influence on adult health. However, more studies are being conducted to elucidate the complex relationships between health, activity and fitness during childhood, adolescence and into adulthood. Physical activity has been shown to be important for improving the health of the overweight, obese or Type 2 diabetic child and adolescent. Strategies to enhance physical activity have often been focused within schools, although the amount of PE and games within schools is often a legislative matter in many countries and therefore prone to political changes. Wider strategies beyond the school gate have highlighted the importance of trying to engage with as many organisations as possible to maximise effectiveness. To this end a clear lead by Government departments and world agencies e.g. the World Health Organisation must be sought to promote physical activity as a cornerstone to good health.

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