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CONTENTS

OBESITY, BODY FAT DISTRIBUTION AND ITS IMPACT ON HEALTH: A ROLE FOR VEGETARIAN DIETS?

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ABSTRACT

Body fat distribution, particularly intra-abdominal fat has been shown to be associated with the development of metabolic disorders such as diabetes and cardiovascular disease (CVD). Hyperinsulinemia and insulin resistance is associated with an atherogenic plasma lipid profile. Studies have demonstrated that abdominal obesity is a predictor of insulin resistance. Computerized axial tomography (CAT) studies have shown that deep abdominal fat is correlated with the level of plasma glucose and total cholesterol levels in both men and women. Some complications of obesity improve with weight reduction. Changes in body weight, particularly a decrease in abdominal fat are strongly correlated with improvement in plasma glucose and lipid metabolism. There is some evidence that the composition of the diet may influence the pattern of weight loss. Attempts have been made in showing the benefits of the vegan diet (does not include animal products) versus the omnivorous diet (includes animal products) in diabetes control. One problem with these studies has been the fact that weight loss has confounded the results of blood sugar control levels, and one of these studies have analyzed the effects of the vegan or lacto-ovo-vegetarian diet on total and regional body composition.

Key words: obesity, body fat, intra-abdominal fat, diabetes, cardio-vascular disease, vegan, lacto-ovo-vegetarian

INTRODUCTION

Diabetes is a chronic and potentially disabling disease that is an emerging major public health concern [19]. It is estimated that 16 million people in the US have diabetes, and it is nearing epidemic proportions [1]. Diabetes is a major contributing factor for heart attack and other macro vascular diseases, as well as the major cause of adult blindness, End Stage Renal Disease and other micro vascular pathologies. The estimated cost of diabetes is over 98 billion dollars per year [13]. Diabetes is the seventh leading cause of death [2] and its link to mortality is under reported [32]. Costs of this devastating disease are estimated at over 98 billion dollars per year.

The pathophysiology of type 2 diabetes is well defined, but primary causes are much less well understood. Factors contributing to type 2 diabetes include genetic dysfunction as well as insulin resistance, which is the earliest predictor of type 2 diabetes [23]. Many patients with type 2 diabetes have hyperglycemia as a result of deficiencies in insulin secretion and insulin action, beta-cell dysfunction and insulin resistance. Defects in insulin secretion and insulin action occur early in the pathogenesis of diabetes [14].

The purpose of this article is to explore the existing evidence of the effects of body fat distribution on diabetes and its co-morbidities, and to review the work that has been done to date of the effects of the vegan (no animal products) and lacto-ovo-vegetarian (includes dairy products) diets on diabetes control and body composition.

Visceral fat obesity

Visceral fat obesity (VFO) with predominant intra-abdominal fat accumulation has been shown to be more often associated with metabolic disorders than subcutaneous fat obesity (SFO). Vague et al. [29] described these subcategories of obesity android and gynoid, respectively, signifying that they are typically male or female but that both types may occur in both sexes. This classification was significant because it was the first to associate android obesity with disease conditions such as diabetes mellitus, gout and atherosclerosis.

Hyperinsulinemia as a cardiovascular disease risk factor (CVD)

The Gothenburg epidemiological study provided evidence that centrally distributed fat in middle aged men is a good predictor of CVD and death [22]. CVD risk seems to increase prior to the onset of non-insulin dependent diabetes mellitus (NIDDM). The roles of obesity and central distribution of body fat, as well as hyperinsulinemia, have been examined among Hispanic and white male and female subjects in the San Luis Valley Diabetes Study with impaired glucose tolerance could be explained by fasting insulin, obesity, and/or central body fat distribution. Central fat distribution was defined as the ratio of the subscapular to triceps skinfold measurements (STR).

Hyperinsulinemia, obesity, and central body fat distribution accounted for some, but usually not all, of the less favorable CVD risk factor pattern in subjects with impaired glucose tolerance. However, HDL-cholesterol and its sub-fractions were found to be significantly lower in Hispanic compared to white females. Higher triglyceride levels were also observed in Hispanic females. The authors postulated that central body fat distribution may be a more important determinant of HDL-cholesterol in females than in males, this being mediated by increased androgenization, especially in females [7].

Peiris et al. [27] in a study of premenopausal women assessed total body fat mass by hydrostatic weighing, and fat distribution by subscapular skinfold thickness, STR, waist to hip ratio (WHR) and computed tomography (CT). CVD risk was assessed by serum insulin response during oral glucose stimulation, levels of triglycerides, total cholesterol, HDL-cholesterol to total cholesterol ratio, and systolic and diastolic blood pressures. Visceral fat distribution assessed by CT accounted for a significantly greater degree of variance in CVD risk than total body fat mass. Cumulative insulin response was the main variable relating anthropometric indices to CVD risk [27].

Insulin resistance is associated with an atherogenic plasma lipid profile. Elevated plasma insulin concentrations enhance very low density lipoprotein (VLDL) synthesis, leading to hypertriglyceridemia. Progressive elimination of lipid and apolipoproteins from VLDL particles leads to increased formation of intermediate lipoproteins (IDL) and low density lipoproteins (LDL), both of which are atherogenic [9].

In a mixed population of Mexican-Americans and non-Hispanic whites in the San Antonio Heart Study [15], it was found that higher levels of total cholesterol and triglyceride, and lower levels of high density lipoprotein-cholesterol (HDL-cholesterol) concentrations were strongly associated with hyperinsulinemia and hypertension in both Mexican Americans and non-Hispanic whites. After adjusting for plasma insulin, only hypertriglyceridemia was associated with high blood pressure, and with no ethnic differences [15].

Evidence suggests that obesity is associated with increased insulin secretion. However, upper body obesity is associated with reduced hepatic insulin extraction and decreased insulin clearance. In premenopausal obese women, body fat mass and body mass index (BMI) have been found to be significantly correlated with plasma glucose, insulin and connecting C-peptide areas after glucose challenge. Trunk fat accumulation and the size of fat cells in the abdomen were also correlated with post-glucose insulin levels [12].

The Insulin Resistance and Atherosclerosis Study [IRAS; 21] included African-Americans, Hispanics and non-Hispanic whites. This study demonstrated that abdominal obesity is a strong predictor of insulin resistance and fasting insulin levels, both known CVD risk factors, in all of these ethnic groups.

Abdominal and intra-abdominal fat as a risk for CVD

In the San Antonio Heart Study, STR and WHR were associated with high non-insulin dependent diabetes mellitus (NIDDM) rates, low HDL-cholesterol levels, and high triglyceride levels; although WHR was a stronger predictor of these than STR. BMI, WHR and STR were independent predictors of NIDDM and plasma HDL-cholesterol in females. However, in males WHR and STR made independent contributions to the prediction of plasma triglyceride levels [18].

Computerized axial tomography (CAT) studies conducted to assess the association between deep and sub-cutaneous abdominal adipose tissue and plasma lipoproteins levels in premenopausal obese women have shown that plasma lipoprotein concentrations were not significantly correlated with total fat mass. However, CAT scan results indicated that the total amount of deep abdominal fat was negatively correlated with HDL-cholesterol levels, as well as with HDL-cholesterol/LDL-cholesterol, HDL apo A/LDL apo B, and HDL_2-cholesterol/HDL_3-cholesterol ratios [10].

Intra-abdominal fat has been found to be positively correlated with hepatic triglyceride lipase. This association seems to be independent of total adiposity. Plasma post-heparin LPL and abdominal adipose tissue lipoprotein lipase (AT-LPL) showed no significant correlation with lipoprotein levels; whereas femoral AT-LPL activity was positively correlated with the HDL_2-cholesterol/HDL_3 -cholesterol ratio. However, hepatic triglyceride lipase activity was found to be negatively correlated with HDL_2 -cholesterol, but not with HDL_3 -cholesterol. The results of this study suggest that the high hepatic triglyceride lipase activity in obese women with an increased amount of deep abdominal fat could be the cause for the decrease in plasma HDL_2 -cholesterol levels [11].

The visceral to subcutaneous fat ratio (V/S) has been found to be significantly correlated with the level of plasma glucose after glucose loading, and with total cholesterol levels in men and women, even after adjusting for BMI and age [16].

Bjorntorp [4] explained the role of intra-abdominal fat in CVD in the following way "Intra-abdominal adipose tissue has an exceedingly sensitive system for the mobilization of free fatty acids (FFA) due to a preponderance of β-adrenergic receptors and little β-adrenergic inhibition" [4]. Bjorntorp [3] further suggests that "portal FFA from the highly lipolytic portal tissues might inhibit hepatic insulin uptake and produce peripheral hyperinsulinemia, perhaps via the accumulation of triglycerides. Increased triglyceride content of the liver and elevated secretion from the liver carried in the VLDL, the main carrier of triglycerides, might explain the elevated plasma concentration of this lipoprotein in android obesity. Both peripheral hyperinsulinemia and tryglyceridemia would result".

Hypertension is another risk factor for CVD. Data from the first Health and Nutrition Examination Survey (HANES), 1971–1974 [5], examined the relationship between blood pressure and the distribution of subcutaneous fat in 5506 survey participants, ages 30 to 59 y. With triceps and subscapular skinfolds used to assess peripheral and central body fat distribution. Blood pressure of middle-aged Americans was found to be associated with central body fat distribution. This finding was true across race and sex groups, and was independent of age [5].

Low levels of HDL-cholesterol have been associated with atherosclerosis. A study of post-menopausal women found that intra-abdominal obesity as assessed by magnetic resonance image (MRI) had a positive correlation with the fractional catabolic rate (FCR) of high density lipoprotein A-1 (Lp-A-1). This particle has been reported to be a better acceptor of cholesterol compared to the HDL particle that contains both the AI and AII apolipoproteins. This may be one mechanism by which intra-abdominal fat may contribute to the development of atherogenesis [30].

Impact of weight loss no intra-abdominal and abdominal fat

Some complications of obesity improve with weight reduction. Fujioka et al. [17] investigated premenopausal women in whom weight reduction was achieved by means of a low calorie diet. Changes in body weight, BMI, total and regional fat volumes and changes in glucose and lipid metabolism showed that the decreased visceral to subcutaneous fat ratio

(V/S ratio) and visceral fat volume were strongly correlated with improvement in plasma glucose and lipid metabolism [17].

Wadden et al. [31] examined changes in body fat distribution in women who lost an average of 12.3 kg from an initial weight of 103.6 kg. WHR decreased 1.2%, implying a reduction in upper body obesity. Subjects with greater upper body obesity tended to achieve greater reductions in WHR. The changes in five circumference measures were correlated with fat loss, and showed that subjects with lower body obesity lost large amounts of fat from both their upper and lower fat depots. Women with lower body obesity tended to lose more total body fat than did women with upper body obesity. The reduction in upper obesity is potentially beneficial because it may reduce the risk of diabetes and CVD [31].

Alterations in the structure or the sub-population distribution of plasma lipoproteins have been shown to contribute to early development of coronary heart disease. Peeples et al. [26] concluded that LDL subfractions in middle-aged non-obese males with abdominal body fat distribution, had a lower molecular weight, higher hydrated density, and smaller particle diameter than LDL of subjects with gluteofemoral adiposity. These LDL characteristics have been associated with CVD.

Vegetarian diets, body fat and diabetes control

There is epidemiological evidence, which has demonstrated a lower incidence of diabetes in lacto-ovo-vegetarians, (the lacto-ovo-vegetarian diet excludes meat and fish, but includes dairy and eggs) than in omnivores (the omnivorous diet includes meat, poultry and sea food). These results suggest that ingestion of a lacto-ovo-vegetarian diet independent of over or underweight and physical activity may be beneficial in diabetes prevention [28]. Vegetarians are reported to be leaner than omnivores. Therefore, the hyperinsulinemia and decreased insulin sensitivity seen in obesity is lower in vegetarians.

There have been some attempts at showing the benefit of a vegan (the vegan diet does not include any animal products) versus the omnivorous diet in diabetes control. One problem with these studies has been the fact that weight loss has confounded their effects on blood sugar control and none of these studies have analyzed the effect of the vegan or lacto-ovo-vegetarian diets on total and regional body composition [6,8,25].

Bruns [6] suggests a lacto-ovo-vegetarian diet and weight loss for the control of diabetes type 2. Crane and sample [8] reported regression of diabetic neuropathy with a vegan diet plus exercise in type 2 diabetics admitted to an in-residence life-style program for 25 days. The subjects in this study had an average weight loss of 4.9 ± 2.6 kg during the 25 days.

Nicholson et al. [25] investigated glycemic and lipid control in patients with non-insulin dependent diabetes. These patients received a vegan diet low in fat. Results showed that the use of a vegan diet in patients with diabetes type2, was associated with significant reduction in fasting serum glucose concentration and body weight without including exercise as part of the treatment.

The use of a low-fat vegetarian diet in patients with NIDDM has been associated with significant reductions in FBS and body weight. A predominantly vegetarian diet may be beneficial in patients with diabetic nephropathy. Patients on a diet high in vegetable protein and low in animal protein have a lower fractional albumin clearance and urinary creatinine compared to patients on a high animal protein diet low in vegetable protein [20].

There is evidence that the composition of the diet may influence the pattern of weight loss. Nagao et al. [24] reported a greater decrease in total fat, visceral fat and subcutaneous fat in subjects fed diacylglycerol enriched diet compared to subjects whose dietary fat intake was composed of triacylglycerides, in spite of weight loss in both groups.

CONCLUSION

In summary, body fat distribution is critical in the development of obesity's co-morbidities, such as diabetes and CVD. There is ample evidence of the detrimental effects on health caused by centrally distributed fat especially intra-abdominal fat.

There is a need to test the effects of a vegetarian diet on total and regional body composition to evaluate their effect on this critical component that contributes to the development of diabetes and its complications. We are not aware of studies testing the dietary composition of a vegan or a lacto-ovo-vegetarian diet on body fat distribution, particularly its effect on intra-abdominal fat and its metabolic consequences. There is also a need to test the effects of a vegan and lacto-ovo-vegetarian diets on blood sugar control without weight loss.

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CHANGES IN BONE MINERAL DENSITY WITH WEIGHT LOSS IN OBESE POSTMENOPAUSAL WOMEN

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ABSTRACT

The effects of a nine months weight loss program using Phenteremine Hydrochloride (Fastin® Smith Kline Beecham) on total and regional bone mineral density (BMD), bone mineral content (BMC) and bone area were assessed by fan beam dual-energy X-ray absorptiometry (Hologic 4500A, V81.a) in forty nine stable postmenopausal Caucasian women with a mean age 56 and a mean BMI 37. We used a partial crossover design in which twenty-four subjects (treatment) began weight loss immediately, while twenty-five subjects (control cross-over) delayed initiation of weight loss intervention for three months. The weight loss program for the treatment group resulted in a significant ($p<0.0001$) weight loss of –7.2% (7 kg) and –10.5% (10 kg) at three and six months respectively. For the control cross-over group, weight loss was also significant ($p<0.0001$) losing –5.5% (5.3 kg) and –8.8% (8.5 kg) at six and nine months respectively. After six months intervention, in the treatment group BMD increased 1.3% ($p<0.05$) in BMD, total body area decreased –1.4% ($p<0.05$) and lumbar spine area increased 1.1% ($p<0.05$). For the control-crossover group at three months total body BMD decreased –1% ($p<0.0001$) and total body BMC decreased –0.7% ($p<0.05$). At six months total body bone area decreased –0.8% ($p<0.05$). At nine months there was a 1.4% ($p<0.0001$) increase in lumbar BMC L1-L4 and a 1.7% ($p<0.05$) increase in lumbar spine area L1-L4. We found that weight loss in these groups of Caucasian post-menopausal women was associated with small changes in BMD, BMC, total body area and lumbar spine area.

Key words: bone mineral content, bone mineral density, weight loss

INTRODUCTION

Studies show conflicting results of the effect of weight loss on changes on bone mineral content (BMC) and bone mineral density (BMD). Jensen et al. [3] found a significant loss of 171.6 g in total body bone mineral (TBBM) in a group of women that lost 12.2 kg weight over a 15-week period. Ramsdale et al. [7] studied moderately overweight pre-menopausal women before and after dietary restriction, in the first three months of the study the women had a mean weight loss of 3.4 kg. This loss was accompanied by significant loss of 0.7% and 0.5% BMD in the total body and lumbar spine respectively after six months. Patel et al. [5] found that weight change in a longitudinal study of postmenopausal women did not cause systematic errors in the results of DXA bone density estimates studies but may adversely affect precision. Van Loan et al. [11] found a significant decline in BMD (1.4%) without a loss in BMC with a weight loss of 15.6 kg after 15 weeks. Bolotin [1] after conducting a series of quantitative simulation studies replicating DXA BMD measurements concluded that the changes in measured BMD with changes in body weight or body fat are artifacts of the systematic errors inherent in planar DXA methodology.

We conducted this study to assess the effects of weight loss in obese Caucasian post-menopausal women on bone mineral content (BMC) and bone mineral density (BMD), using the fan beam Hologic 4500A densitometry scanner. We hypothesized a 1%–2% decline in BMD with six months of weight loss.

MATERIALS AND METHODS

Subjects

Forty-nine postmenopausal Caucasian women aged 40 – 70 years old on hormone replacement therapy (HRT) were recruited by direct mailings, and advertising in the Loma Linda University's FYI paycheck enclosure. The women participated for 6 months in a prospective weight loss clinical trial to examine the effects of weight loss on total-and regional-body composition. The women were randomly assigned to control cross-over or treatment groups using a random digits table. Their inclusion in the study entailed a body mass index (BMI) of 30 or greater, plus a cardiovascular disease risk factor, e.g., hypertension, diabetes mellitus, hyperlipidemia, or degenerative joint disease.

Women were excluded if they had participated in any weight control program in the previous three months, were taking any serotonion-reuptake inhibitors, had uncontrolled hypertension, hyperthyroidism, hypersensitivity to symathomimetic amines, glaucoma, agitated states, history of drug abuse, or had taken in the previous two weeks or were presently taking monoamine oxidase inhibitors [6]. The study protocols were approved by our Institutional Review Board (IRB). All subjects signed an informed consent before enrolling into the study.

Experimental Design

The study used a partial crossover design in which half of the subjects were randomly assigned to treatment and began the weight loss intervention immediately, and continued for six months, while the other half the control cross-over group delayed initiation of any weight loss intervention for 3 months. Then they were followed for weight loss for an additional six months.

Treatment

A medically supervised program using Phenteremine hydrochloride (Fastin® SmithKline Beecham Pharmaceuticals, Philadelphia, PA) was selected for this study. After the initial physical screening, both control cross-over group and treatment groups were given monthly check-ups by the physician or nurse educator. Patients in the treatment group were instructed to follow a 1200-calorie diet and were prescribed Fastin® 15 mg/day once a day; if appetite or weight remained unchanged by the next monthly appointment, the dose was increased to 15 mg twice a day (8:00 A.M. and 5:00 P.M). In addition attendance to monthly support sessions was required. The support sessions provided skill-building techniques to encourage behavior changes in stress management, exercise, nutrition and management of emotions without excess food consumption. Patients were encouraged to set an exercise goal for themselves, example, walking. The guidelines of the American College of Sports Medicine were followed. These included an increase of 105 effort/week, which equals to approximately an increase of 1 to 2 minutes of exercise per week. In addition to the intake of 1200 calories, nutritional counseling included recommendations to eat at regular meal times and to keep food records for self-monitoring. For the management of emotions, recommendations were made to deal with stressful situations, for example, instead of eating, call a friend to vent feelings, exercise or do a pleasant task.

The control cross-over group did not follow a 1200-calorie diet or attended the group sessions for the first three months. Four women in the control cross-over group and none in the treatment group dropped out of the study at three months; those remaining attended all medical, DXA scans and anthropometric measurements.

The treatment and control cross-over group each received Fastin® therapy for six months, the treatment group from September to March and the control-cross over group from December to June. At the end of 6 months, the treatment group suspended Fastin® therapy, but continued the low energy diet and group sessions.

Dual Energy X-ray Absorptiometry (DXA)

Total and regional body composition was measured by dual energy x-ray absorptiometry, (Hologic QDR 4500A. Hologic Inc., Waltham, MA). The hardware for this technique has an x-ray tube equipped with a filter to convert the polychromatic x-ray beam into low- and high-energy peaks. The software used for image analysis and calculations was version V8.1a. Scans were obtained with the women lying supine and wearing only a hospital gown. All metal jewelry was removed. Whole body scan took approximately 3 minutes, and radiation exposure was 1.5 mrems (0.00015 Sieverts). DXA scans were obtained at baseline, three, six, and nine months. In addition all women were scanned for spine BMD measurements using a standard protocol. To minimize operator variation, the same two trained technicians performed the DXA scans throughout the study.

Statistical analyses

The data analyses for baseline is based on the 49 women who enrolled in the study. For measuring changes in BA, BMC and BMD over nine months, the analysis included 45, 43, and 38 women at three, six and nine months, respectively. All statistical analysis was performed with the statistical package for the Social Sciences. SPSS 8.0 versions (SPSS Inc. Chicago IL.) Independent t-tests were used to assess differences between the control and treatment groups. Paired t-test was used to assess weight reduction and to determine its impact on bone measurements. The percent mean difference between baseline and three, six and nine months was calculated as

$$\% \text{ Mean difference} = (\text{Baseline- } (X) / \text{baseline}) \times 100$$

$$X = 3, 6 \text{ and } 9 \text{ months}$$

RESULTS

Table 1 summarizes the descriptive characteristics of the control cross-over and treatment groups and the mean and standard deviation for total body BMC (gms), lumbar (L1–L4) BMD (gm/cm^2), lumbar (L1–L4) BMC (gm), fat-free mass (kg), % total fat, % trunk fat, % arm fat, and % leg fat. The difference at baseline between the groups is not significant for any variables.

Table 1. Descriptive characteristics at baseline of control cross-over and treatment groups in postmenopausal women ($\bar{x}$ ±SD).

Variable	Control (n=25)	Treatment (n=24)	
Age (years)	55.88 ± 4.85	56.08 ± 6.68	–0.12
Height (cm)	162.05 ± 5.87	162.03 ± 6.07	0.01
Weight (kg)	98.71 ± 16.76	95.40 ± 17.00	0.69
BMI (kg/m^2)	37.47 ± 5.27	36.36 ± 6.37	0.67
Total BMC (gms)	2262.52 ± 281.38	2176.12 ± 404.70	0.75
Total Lumbar BMD (gm/cm^2)	1.07 ± 0.17	1.03 ± 0.18	0.87
Estimated Total Lumbar BMC (gms)	60.24 ± 12.03	58.65 ± 13.36	0.44
Total Area (cm^2)	2028.05 ± 141.37	1971.08 ± 150.44	1.37
Fat-free mass (kg)	42.52 ± 5.46	41.61 ± 5.68	0.57
% Total fat	50.70 ± 4.96	50.40 ± 4.23	0.23
% Trunk fat	50.62 ± 5.47	50.50 ± 4.53	0.08
% Arm fat	57.45 ± 6.56	56.88 ± 7.71	0.28
% Leg fat	52.35 ± 5.45	52.05 ± 5.52	0.20

Table 2 shows the percent mean differences for the treatment group after three and six months. As assessed by paired t-test there was a significant ($p<0.0001$) weight reduction after three (by –7.2% or 7 kg) and six (by –10.5% or 10 kg) months. Total body BMD shows a significant increase (1.3%, $p<0.05$) after six months. Total body area decreased significantly after six months of treatment (–1.4%, $p<0.05$). Lumbar spine area (L1–L4) increased significantly after six months (1.1 %, $p<0.05$). No other significant BMD changes were found in the treatment group.

Table 2. Bone density changes in the treatment group at 3 months (n=24), 6 months (n=23).

Variable	Baseline Mean ± SD	Mean ± SD	% Mean Difference	p value
Weight (kg) 3 mo.	95.40 ± 17.00	88.52 ± 17.52*	–7.21	0.000*
Weight (kg) 6 mo.	94.70 ± 17.03	84.76 ± 17.49*	–10.50	0.000*
Total Body BMD (gm/cm^2) 3 mo.	1.10 ± 0.13	1.09 ± 0.13	–0.18	0.677
Total Body BMD (gm/cm^2) 6 mo.	1.10 ± 0.14	1.11 ± 0.14	1.28	0.006**
Total Body BMC (gms) 3 mo.	2176.13 ± 404.70	2164.21 ± 401.74	–0.55	0.134
Total Body BMC (gms) 6 mo.	2180.34 ± 413.26	2176.57 ± 416.89	–0.17	0.649
Total Body Area (cm^2) 3 mo.	1971.08 ± 150.44	1963.53 ± 156.58	–0.38	0.203
Total Body Area (cm^2) 6 mo.	1972.79 ± 153.58	1945.09 ± 159.98	–1.40	0.006**
Lumbar BMD (gm/cm^2) 3 mo. (L1–L4)	1.03 ± 0.18	1.03 ± 0.19	–0.48	0.366
Lumbar BMD (gm/cm^2) 6 mo. (L1–L4)	1.04 ± 0.18	1.03 ± 0.19	–0.53	0.392
Lumbar BMC (gms) 3 mo. (L1–L4)	58.65 ± 13.36	58.65 ± 13.44	0.00	1.000
Lumbar BMC (gms) 6 mo. (L1–L4)	59.33 ± 13.23	59.69 ± 13.60	0.60	0.443
Lumbar Spine Area (cm^2) 3 mo. (L1–L4)	56.47 ± 6.06	56.78 ± 5.52	0.55	0.134
Lumbar Spine Area (cm^2) 6 mo. (L1–L4)	56.97 ± 5.67	57.61 ± 5.29	1.13	0.002**

Significant at p<0.0001*
Significant at p<0.05**
Scans were not done at nine months for the treatment group

$$\% \text{ Mean Difference} = \frac{\text{(Variable Mean – Baseline Mean)}}{\text{Baseline Mean}} \times 100$$

Table 3 gives the percent mean differences for the control-cross over group at three, six and nine months. Body weight did not change (p>0.05) after three months. However, weight loss was significant (p<0.0001) at six months by –5.5% or 5.3 kg, and nine months by –8.8% or 8.5 kg in response to the treatment. Total body BMD is significantly lower at three months (–1.2, p<0.0001), as well as total body BMC (–0.7 %, p<0.05). Total body area at six months significantly decreased (–0.8 %, p< 0.05). Lumbar BMC (L1–L4) increased significantly at nine months (1.4 %, p<0.0001). Lumbar spine area (L1-L4) at nine months also increased significantly (1.7 %, p<0.05). There are no other significant changes after three, six or nine months. Figure 1 shows the changes in total and lumbar BMD after three and six months of treatment.

Table 3. % bone density changes in the control-cross over group at 3 months (n=20), 6 months (n= 19) and 9 months (n=17).

Variable	Baseline Mean ± SD	Mean ± SD	% mean difference	p value
Weight (kg) 3 mo.	98.33 ± 16.62	99.02 ± 16.95	0.70	0.122
Weight (kg) 6 mo.	97.11 ± 16.14	91.79 ± 15.00	–5.47	0.000*
Weight (kg) 9 mo.	97.18 ± 16.87	88.68 ± 15.69	–8.75	0.000*
Total Body BMD (gm/cm^2) 3 mo.	1.11 ± 0.09	1.10 ± 0.09	–1.17	0.000*
Total Body BMD (gm/cm^2) 6 mo.	1.11 ± 0.09	1.11 ± 0.09	0.45	0.185
Total Body BMD (gm/cm^2) 9 mo.	1.10 ± 0.09	1.10 ± 0.10	0.00	0.725
Total Body BMC (gms) 3 mo.	2263.95 ± 245.98	2248.12 ± 237.03	–0.70	0.045**
Total Body BMC (gms) 6 mo.	2247.48 ± 241.12	2237.73 ± 245.59	–0.43	0.257
Total Body BMC (gms) 9 mo.	2248.05 ± 251.59	2225.43 ± 238.77	–1.01	0.101
Total Body Area (cm^2) 3 mo.	2031.26 ± 136.37	2042.47 ± 143.21	0.55	0.074
Total Body Area (cm^2) 6 mo.	2022.34 ± 133.97	2005.06 ± 140.17	–0.85	0.008**
Total Body Area (cm^2) 9 mo.	2033.27 ± 133.80	2013.50 ± 132.30	–0.97	0.056

Variable	Baseline Mean ± SD	Mean ± SD	% mean difference	p value
Lumbar BMD (gm/cm^2) 3 mo. (L1–L4)	1.06 ± 0.16	1.06 ± 0.16	–0.66	0.320
Lumbar BMD (gm/cm^2) 6 mo. (L1–L4)	1.05 ± 0.16	1.04 ± 0.16	–0.95	0.249
Lumbar BMD (gm/cm^2) 9 mo. (L1–L4)	1.04 ± 0.16	1.04 ± 0.17	–0.29	0.583
Lumbar BMC (gms) 3 mo. (L1–L4)	60.42 ± 10.32	59.61 ± 10.01	–1.34	0.087
Lumbar BMC (gms) 6 mo. (L1–L4)	59.90 ± 10.33	60.10 ± 11.05	0.33	0.717
Lumbar BMC (gms) 9 mo. (L1–L4)	59.74 ± 10.94	60.55 ± 11.66	1.35	0.000*
Lumbar Spine Area (cm^2) 3 mo. (L1–L4)	56.81 ± 4.39	56.34 ± 4.24	–0.83	0.074
Lumbar Spine Area (cm^2) 6 mo. (L1–L4)	56.90 ± 4.49	57.45 ± 4.80	0.97	0.067
Lumbar Spine Area (cm^2) 9 mo. (L1–L4)	57.27 ± 4.52	58.23 ± 4.66	1.68	0.010**

Significant at $p<0.0001$*
Significant at $p< 0.05$**

$$\% \text{ Mean Difference} = \frac{\text{(Variable Mean – Baseline Mean)}}{\text{Baseline Mean}} \times 100$$

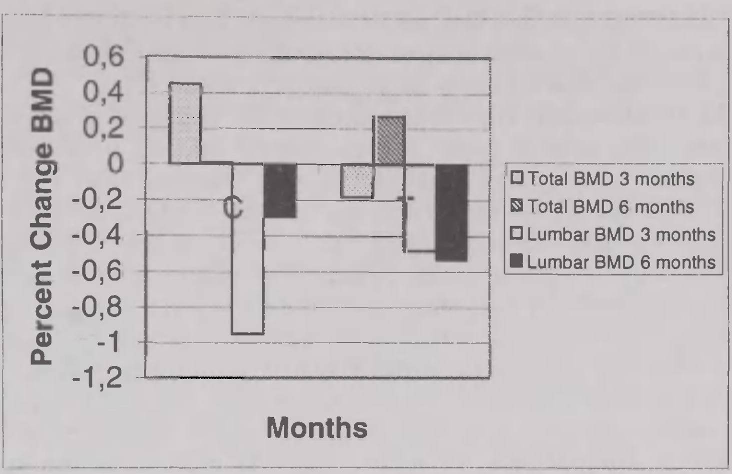

Figure 1. The change in total and lumbar BMD at 3 and 6 months after weight loss in control crossover and treatment groups.

DISCUSSION

The results of our study are the first to examine weight loss in post-menopausal Caucasian women using fan beam DXA Hologic 4500A (software V8.1a).

Prior to conducting this study, we assessed the reproducibility of lean, fat and bone measurements with Hologic 4500A in 9 Caucasian post-menopausal women. Each of the women was scanned twice the same day. Measurements were made using the Hologic 4500A (software V8.1a). Our results showed a CV for total fat, lean tissue and total bone mineral to be 1.4, 1.4 and 2.1 % respectively [2].

In the control cross-over group after three months we found a decrease in total body BMD, BMC, and at six months a decrease in total body area. Both the control cross-over group and the treatment group after six moths of weight loss treatment showed an increase in lumbar spine area. Changes in total body BMD and BMC amount to less than –1.4 %. Total body bone area changes range from –0.8 % to 1.4% and lumbar spine area from 1.1 % to1.7 %.

Some of our results are similar to those reported by Van Loan et al. [11] (Lunar, software 3.6z) who studied effects of weight loss on bone health of fifteen moderately obese women and found a decline in BMD without a change in bone area or in BMC. The authors suggested that changes in BMD observed with weight loss might be a result of a lack of instrument sensitivity when body weight and composition change and are simply an artifact and not a physiologic change in BMD [11].

Like Tothill et al. [10] we found that after six months of weight loss treatment, the treatment group had an increase in total BMD and a decrease in total body area. Tothill et al. [10] (Hologic QDR 1000W, whole body enhanced software V5.51 and software for the spine V4.47p) conducted a study over a period of one year in patients with eating disorders and found that a change in total bone mineral content (BMC) correlated positively with a change in weight. However, a loss of weight was associated with an increase in bone mineral areal density (BMD), arising from a reduction in bone area. Phantom measurements offered an explanation of the anomaly in vivo and demonstrated that, under different circumstances, change in both BMC and BMD can be wrongly recorded. The authors concluded that no valid conclusions could be drawn from measurements by Hologic QDR 1000W (pencil beam) of bone changes during weight change.

Patel et al. [5] using more recent software (Hologic QDR 2000, software 5.54) concluded, that weight change in a longitudinal study of post-menopausal women was not found to cause systematic errors in the results of DXA bone densitometry studies. However, obesity and change in weight may have an adverse effect on precision errors in individual patients.

Jensen et al. [3] found considerable TBBM loss (mean 171.6 g) with diet-induced weight loss (mean 12.3 kg) using the DXA scanner Hologic W-1000 (pencil beam, software version 5.11). Ramsdale et al. [7] (pencil beam, Lunar DPX-L, software 1.3) in his study in pre-menopausal women found losses in BMD in the total body (0.7%) and spine (0.5%) and attributed these to a decrease in calcium intake while the women were on a low calorie diet for weight loss.

Ricci et al. [8] studied the effects of energy restriction on bone health in postmenopausal women. Their results showed a 1.15% in TBBMD, 0.5% in TBBMC as (DPX Lunar, software 8.8 G). These results are similar to ours. Bone changes in this group of women seem to be partially regulated by an increases in parathyroid hormone as reported by the authors.

Shapses et al. [9] observed that pre-menopausal women undergoing weight loss while on a calorie restricted diet with calcium supplementation showed an increase in lumbar BMD by 1.7% compared with the placebo group (DPX Lunar, software 8.8 G). This group of pre-menopausal women who lost a moderate amount of body weight (7–8%)

did not loose bone within the total body or lumbar spine, even when the calcium intake was deficient.

Jensen et al. [4] in a mixed group of pre-menopausal and postmenopausal women not on hormone replacement therapy, found also bone changes after weight loss.

In this study the treatment group received one gram/day of calcium supplement while the control group did not receive the supplement. Both groups underwent weight loss treatment. The control group lost 1% of TBBM and the supplemented group lost 2% of TBBM after the first month (Hologic QDR-2000 pencil beam). After six months the control had a decrease of 2.2% in the lumbar spine while the supplemented group lost only 0.2%. The authors concluded that bone loss is inevitable when there is weight loss, and that the changes in bone loss can be reduced with calcium supplementation.

In conclusion, we found that weight loss in these groups of Caucasian post-menopausal women was associated with small but statistically significant increase and a decrease in total body BMD. There was a decrease in total body BMC and in total body bone area and an increase in lumbar BMC and lumbar spine area as assessed by the Hologic 4500A fan beam DXA scanner.

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CORRELATIONS OF PLASMA LEPTIN LEVELS WITH SUBCUTANEOUS ADIPOSE TISSUE DISTRIBUTION IN OBESE BOYS BEFORE, AND AFTER A SPORT AND DIET INTERVENTION

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ABSTRACT

Leptin is a key factor in the regulation of energy homeostasis and body fat mass. It is secreted by white adipocytes to a higher rate from subcutaneous fat tissue than from visceral fat. To date, no study compared the effects of a diet and sport intervention programme in obese boys with respect to subcutaneous adipose tissue topography (SAT-Top) and its variation versus total body fat mass (FM) and putative influences on serum leptin levels.

32 obese boys [age: 11.9±1.7y (8.9–14.7); body weight: 65.1±14.7kg (34.2–98.8)] were investigated before and after a three weeks diet and sport programme. Leptin was measured by RIA, FM was assessed by BIA (FM_{BIA}) and LIPOMETER (FM_{LIPO}). SAT-Top was assessed by measuring the thickness of the subcutaneous adipose tissue layer at 15 specified body sites by LIPOMETER.

Mean serum leptin levels were reduced to 45.1% ($p<0.001$) and the thickness of 15 measured body sites, especially from the trunk, decreased to 80–90%. A factor analysis revealed that SAT-Top can be expressed by 2 factors. Factor 1 (corresponding to the body sites from the trunk) is strongly reduced by this kind of intervention programme (to 72.2%) while factor 2 (related to body sites of the extremities) was not significantly influenced. However, nearly every measured body site was significantly correlated with leptin levels before and, to a far greater extent, after the intervention. Leptin levels were correlated with FM_{BIA}, FM_{LIPO}, all 15 measured body sites, factor 1 and factor 2, before and after the programme. The highest correlations were obtained with FM_{LIPO} (before: $r=0.63$, $p<0.001$; after: $r=0.74$, $p<0.001$) and factor 1 (before: $r=0.59$, p<0.001; after: r=0.81, p<0.001). Overall, changes in leptin levels were best predicted by initial leptin concentrations (r=0.98, p<0.001).

These results indicate that, i) this kind of intervention programme provides good results in reduction of leptin levels and trunk-SAT thickness, and ii) leptin levels are associated to a greater extent with SAT-Top than total body fat mass in obese boys.

Key words: leptin, fat distribution, body composition, obesity, LIPOMETER, subcutaneous adipose tissue topography, factor analysis

INTRODUCTION

Leptin is a peptide hormone produced by white adipocytes which is involved in the regulation of the body´s energy stores, especially body fat [5, 28]. Leptin was shown to activate distinct projections from the dorsomedial and ventromedial hypothalamic nuclei [7]. Leptin decreases food intake, increases energy expenditure and thermogenesis, and decreases NPY levels.

Fat mass, sex and pubertal maturation are related to plasma leptin concentrations in healthy children and adolescents [3]. Obese children and adults show higher leptin levels compared to subjects of normal body weight and body composition [8, 9]. There is evidence that not only total body fat mass but also the fat distribution is linked with leptin levels [13, 25]. No significant correlations were found between leptin levels and visceral fat area of obese and non obese subjects [26], and a significant reduction in leptin mRNA expression was found in omental adipose tissue [11]. Hence, it is likely that subcutaneous adipose fat depots contribute to circulating leptin in a significant percentage [26]. It has been mentioned that the effect of body fat distribution on serum leptin concentration is independent of body composition [17], and leptin concentrations are more closely linked to subcutaneous than visceral fat mass early in the development of juvenile obesity [4].

There have been found some positive correlations between leptin and subcutaneous fat areas by several investigations [6, 17, 25] moreover, in this study the putative existence of such a dependence by correlating leptin levels with various subcutaneous adipose tissue thicknesses of obese boys before and after a three weeks sport and diet intervention programme is investigated. An additional aim focuses on the influences of this weight reduction programme on leptin levels, total body fat mass and subcutaneous adiposity.

SUBJECTS AND METHODS

Subjects

32 obese boys (age: 11.9±1.7y (8.9–14.7)), participated in a three weeks weight reduction programme during summer holidays. They were assigned to a low caloric diet (2100 kJ to 4200 kJ per day, depending on age and degree of adiposity). Physical activity was performed in three two-hours units per day (biking, swimming, soccer).

Assessment of Body Composition

Total body fat mass (FM_{BIA}) was assessed by Bioelectrical Impedance Analysis (BIA) as described previously [22] with a frequency of 50kHz and 0.8 mA. Additionally, subcutaneous adipose tissue volume (SAT-Vol) and total body fat mass were measured by LIPOMETER (FM_{LIPO}) [14] and calculated on the basis of measured SAT-Top values (see below). SAT-Vol and FM_{LIPO} were obtained as described elsewhere [15]. The validity of this instrument is described by Tafeit et al. [24].

Assessment of Subcutaneous Adipose Tissue Topography (SAT-Top)

Subcutaneous adipose tissue topography (SAT-Top) was determined by means of the optical device LIPOMETER. SAT-Top is composed of the subcutaneous adipose tissue thicknesses in mm at 15 specified sites of the human body. Previously, we reported on the exact anatomical location of these body sites [16]. Measurements were performed at the right body side while the subjects were in upright position.

Measurement of leptin and insulin

Blood samples were taken after an overnight fast before measurements of body composition, at the first day (*pre*) and after three weeks (*post*) of intervention. Serum leptin [3] and serum insulin were measured by means of RIA, commercially available from Linco, Research MO. The sensitivity was tested to be 0.03 ng per ml. All *pre* and *post* samples were run in the same assay.

Statistics

Statistical analysis was conducted utilising SPSS for WINDOWS. Kolmogorov-Smirnov test was used to investigate if data were normally distributed. The hypothesis of differences in distributions of values before and after the training period was tested by t-test. Pearson correlation and linear regression were used to identify association between variables of interest. P-values less than 5% were considered significant.

Finally, SAT-Top of the 32 obese boys before and after the weight reduction programme is depicted in a factor plot to show changes of their subcutaneous fat distributions and the relationship to lean healthy subjects. We recently reported about this factor analysis of SAT-Top from 590 healthy subjects [16]. In brief, two factors were calculated. Factor 1 was related to „trunk", including the SAT-Top information of all body sites from the trunk; factor 2 corresponded to SAT-Top of the extremities. In this way we were able to reduce the 15 dimensional data space of the 15 measurement points to two dimensions, described by the two additional variables factor 1 and factor 2, which can be used as x- and y-coordinates in a factor plot. This approach enables us to condense the SAT-Top information of 15 body sites in one diagram. This was done for 590 healthy men and women, providing the information of their trunk- and extremities-development as a basis for comparison, which we use for the group of obese boys to show the effects of the weight reduction programme in a very condensed form in this factor plot.

RESULTS

Descriptive statistics (mean values, SD´s) are presented in Table 1. All variables were normally distributed. As a result of the weight reduction programme, body weight, body mass index, leptin level, FM_{BIA}, FM_{LIPO}, SAT-Vol, SAT thickness of almost all trunk body sites, and consequently factor 1 (trunk body sites) were significantly reduced (Table 1). Insulin level, two body sites of the lower abdomen region and most body sites from the lower extremities, and consequently factor 2 (which is related to extremities) were not significantly influenced (Table 1). Significant correlations between different personal parameters and their absolute difference (before-after) were found for weight (r=0.85), body mass index (r=0.66), *1-neck* (r=0.43), *2-triceps* (r=0.35), *4-upper back* (r=0.36), *5-front chest* (r=0.35), *6-lateral chest* (r=0.49), *9-lower back* (r=0.41), *11-front thigh* (r=0.52), *12-lateral thigh* (r=0.61), *13-rear thigh* (r=0.58), *14-inner thigh* (r=0.52), FM_{BIA} (r=0.68) and FM_{LIPO} (r=0.59), showing a stronger reducing tendency for those boys with higher absolute measurement values.

The strongest relative reduction was found for leptin levels, which decreased to 45.1% (mean values at the beginning of the intervention were set to 100%). The trunk SAT-Top body sites were reduced to about 80–90%; consequently factor 1 showed a strong decrease to 72.2% (factor

1=–0.5 was set to 0%, which is the average trunk fat development of non-obese boys) (Fig.1).

Table 1. Descriptive statistics (mean, SD) of 32 obese boys before and after a sport and diet intervention programme

Personal parameters	before programme	after programme	significance of differences [1]
age (y)	11.9±1.7		
height (cm)	155.5±10.2		
weight (kg)	65.1±14.7	59.9±13.4	$p<0.001$
body mass index	26.5±3.5	24.3±3.2	$p<0.01$
insulin (mU/ml)	7.1±4.5	6.8±2.2	n.s. [2]
leptin (ng/ml)	12.6±6.4	5.7±2.1	$p<0.001$
FM_{BIA} (kg)	27.8±9.3	22.6±7.9	$p<0.001$
FM_{LIPO} (kg)	20.5±5.7	18.0±4.7	$p<0.001$
SAT-Vol (1)	20.0±5.0	17.3±4.9	$p<0.001$
1-neck [3]	13.9±4.3	11.8±3.8	$p<0.001$
2-triceps	13.0±2.5	11.8±2.6	$p=0.002$
3-biceps	9.1±1.9	8.1±2.1	$p<0.001$
4-upper back	12.5±3.3	10.2±3.1	$p<0.001$
5-front chest	19.3±4.8	16.7±4.7	$p<0.001$
6-lateral chest	12.9±4.1	10.2±3.6	$p<0.001$
7-upper abdomen	18.2±3.7	16.8±4.6	$p=0.036$
8-lower abdomen	14.3±2.9	14.8±3.5	n.s.
9-lower back	13.8±2.8	14.2±3.3	n.s.
10-hip	16.2±3.2	13.4±4.1	$p<0.001$
11-front thigh	9.0±2.0	8.9±2.5	n.s.
12-lateral thigh	10.0±2.7	9.7±2.5	n.s.
13-rear thigh	7.6±2.3	6.9±1.9	$p=0.027$
14-inner thigh	12.0±2.5	11.4±2.5	n.s.
15-calf	6.7±1.6	6.3±1.9	n.s.
factor 1 [4]	1.3±0.7	0.8±0.7	$p<0.001$
factor 2 [5]	0.5±0.4	0.5±0.5	n.s.

[1] by t-test
[2] not significant ($p>0.05$)
[3] subcutaneous adipose tissue (SAT) thickness of 15 body sites in mm
[4] corresponds to trunk-SAT development
[5] corresponds to extremities-SAT development

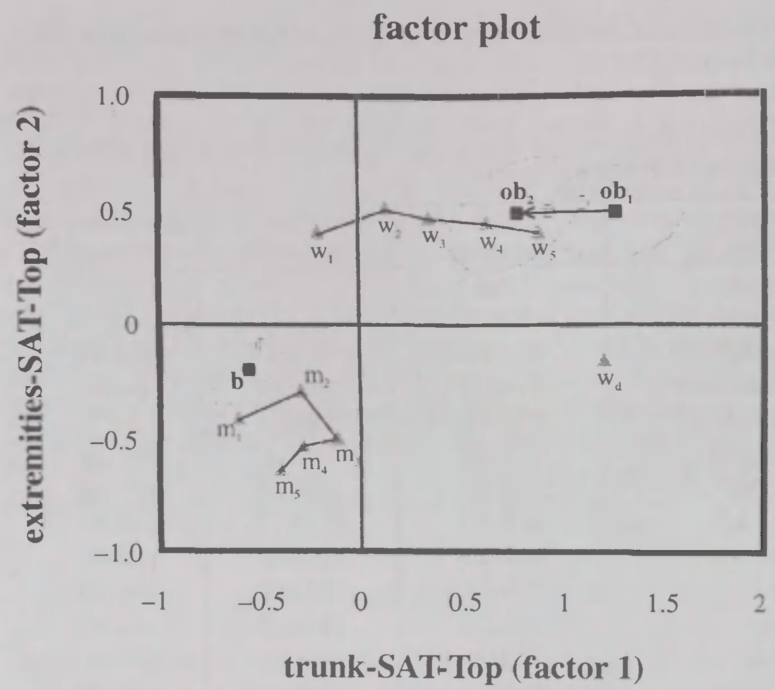

Figure 1. Factor plot showing trunk and extremities-SAT-Top of obese boys before (ob_1) and after (ob_2) a weight reduction programme and their age matched group of non obese boys (b). A 95% confidence ellipse is presented for the means of these groups. The different age groups of healthy men and women (m_1, ..., m_5, w_1, ..., w_5) and diabetic type II (NIDDM) women (w_d) are presented for comparison.

Obese boys showed a very high trunk-SAT-Top before the weight reduction programme (ob_1 in Fig.1); even more than old women and diabetic women did. Surprisingly, just their extremities-SAT-Top is like that of healthy women. The trunk-SAT-Top of obese boys was reduced after three weeks of sport and diet (ob_2), but their subcutaneous fat development is still similar to that of 60 year old women. On the contrary, their age matched group of non obese boys (b) is in the area of men, providing a “normal” male fat pattern. Subcutaneous adipose tissue thickness of the extremities was not changed significantly during the programme; the load of factor 2 was about the same for ob_1 and ob_2.

Correlations between leptin levels and different measurement values are shown in Table 2. In general, values provided higher correlations after the intervention programme. FM_{LIPO}, SAT-Vol, the body sites *1-neck*, *4-upper back*, *6-lateral chest* and *10-hip*, and factor 1 yielded the highest correlations (Table 2 and Fig. 2). Especially, the multiple regression model revealed that the leptin levels before the intervention programme were best explained by the body site *1-neck* ($p < 0.001$). The reduction in leptin levels was strongly associated with leptin levels at the beginning of the intervention programme ($r=0.98$, $p<0.001$).

Though there were also significant correlations between the absolute reduction in leptin levels and the different personal parameters (body mass index, FM_{BIA}, FM_{LIPO}, SAT-Vol, seven SAT-Top body sites and factor 1), an analysis of covariance yielded only two significant measurement values: leptin ($p < 0.001$) and FM_{LIPO} ($p=0.018$), using the absolute leptin difference (before-after) as dependent variable.

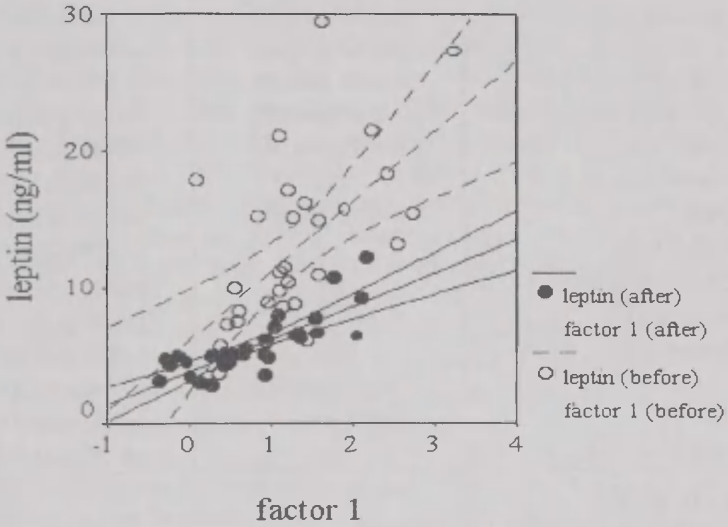

Figure 2. Scatterplot, regression line and 95% confidence interval for leptin levels before and after a weight reduction programme versus factor 1 (trunk-SAT-Top) before ($r=0.59$, $p<0.001$) and after ($r=0.81$, $p<0.001$).

Table 2. Correlations between leptin levels and different personal parameters. Leptin levels before the sport and diet intervention programme are correlated to parameters (before); leptin levels (after) to parameters (after). [n=32].

Personal parameters	leptin levels before (r, p)	leptin levels after (r, p)
insulin (mU/ml)	r=0.43 p=0.014	r=0.37 p=0.038
height (cm)	n.s. [1]	n.s.
weight (kg)	r=0.36 p=0.043	r=0.38 p=0.030
body mass index	r=0.56 p=0.001	r=0.60 p<0.001
FM_{BIA} (kg)	r=0.56 p<0.001	r=0.59 p<0.001
FM_{LIPO} (kg)	r=0.63 p<0.001	r=0.74 p<0.001
SAT-Vol (1)	r=0.61 p<0.001	r=0.74 p<0.001
1-neck	r=0.68 p<0.001	r=0.72 p<0.001
2-triceps	r=0.54 p=0.002	r=0.66 p<0.001
3-biceps	r=0.37 p=0.037	r=0.71 p<0.001
4-upper back	r=0.62 p<0.001	r=0.79 p<0.001
5-front chest	r=0.41 p=0.019	r=0.69 p<0.001
6-lateral chest	r=0.54 p<0.001	r=0.76 p<0.001
7-upper abdomen	r=0.40 p=0.022	r=0.63 p<0.001
8-lower abdomen	r=0.35 p=0.046	r=0.42 p=0.016
9-lower back	n.s.	r=0.64 p<0.001
10-hip	r=0.62 p<0.001	r=0.70 p<0.001
11-front thigh	n.s.	r=0.57 p=0.001
12-lateral thigh	n.s.	r=0.44 p=0.011
13-rear thigh	r=0.48 p=0.005	r=0.45 p=0.010
14-inner thigh	n.s.	r=0.36 p=0.042
15-calf	r=0.39 p=0.027	r=0.46 p=0.009
factor 1 [2]	r=0.59 p<0.001	r=0.81 p<0.001
factor 2 [3]	n.s.	r=0.49 p=0.004

[1] not significant
[2] corresponds to trunk-SAT development
[3] corresponds to extremities-SAT development

DISCUSSION

Our study investigated the influence of a low caloric diet and enhanced physical activity on subcutaneous adipose tissue distribution and leptin levels in obese boys. We found significant changes in body weight, circulating leptin and fat mass, as assessed by two different methods (BIA and LIPOMETER). Additionally, we observed changes in the thickness of subcutaneous adipose tissue of nearly all measured 15 body sites and, especially, in the load of factor 1 (body sites from the trunk).

Interest has been focused on the characteristics of body fat distribution that contributes to circulating leptin in normal-weight and obese adults [10, 12] and in children [17, 19, 20]. However, body fat distribution is often defined as the ratio of intraabdominal to subcutaneous abdominal adipose tissue, measured by different techniques, such as, e.g., magnetic resonance imaging [4, 10, 21], computed tomography [17, 27] or ultrasound [23]. Other studies used the waist-to-hip-ratio [12] or hip circumference alone as a proxy measure of peripheral fat. We, on the other hand, measured the thickness of 15 different body sites to provide a more detailed description of the amount and location of subcutaneous adipose tissue. SAT-Top data show a high correlation with leptin. The essential information of those 15 body sites can be condensed to only two factors, suggesting that subcutaneous adipose tissue topography (SAT-Top) can be adequately expressed by a trunk (factor 1) and extremities (factor 2) subcutaneous obesity. Whereas factor 1-related body sites correlated with leptin levels both before and after the intervention programme (Fig. 2), factor 2-related body sites reached statistical significance with leptin levels only at the end of the three weeks (Table 2). The improvement in the association of both factors with leptin might indicate that a more tight regulated mechanism exists between SAT-Top and corresponding leptin levels after the intervention.

It was shown that the subcutaneous fat depot is the major source for leptin in normal-weight and obese women [26]. There is evidence that ob mRNA is higher in subcutaneous than omental fat tissue [11], and a gender based influence on human leptin mRNA expression has been demonstrated [13]. However, in the study of Alessi et al. [1] a similar secretion rate of leptin from subcutaneous and omental fat tissue was found.

It has to be mentioned that a discordance of ob mRNA with plasma leptin was reported in 53 subjects covering a broad range of adiposity [18]. This would suggest that a high expression rate of ob mRNA in subcutaneous fat tissue is not necessarily associated with an increased concentration of circulating leptin. The assumption that the subcutaneous fat depot is the major source of leptin, therefore, should be further tested with respect to these findings.

Given the likelihood that a mass effect of adipose tissue contributes to circulating leptin [26], the results of observed associations between leptin and the thickness of subcutaneous adipose tissue at certain body sites (factor 1) therefore, might indicate that factor 1-related subcutaneous obesity is a major determinant of leptin in obese boys, especially after the intervention. Interestingly, the change in factor 1 (Table 1, Fig. 1) was not the best predictor to explain the 50 percent reduction in circulating leptin (Table 1). A multiple regression model revealed that 90 percent of the variance in changes of leptin (with the absolute difference in leptin as the dependent variable), was best explained by initial leptin values (model not shown). This is further emphasized by the result of a simple linear regression between changes in leptin and initial leptin values ($r=0.98$, $p<0.001$). This indicates that the higher the leptin level at the beginning, the greater is the reduction after an intervention programme. It is tempting to speculate that a threshold for leptin, independent of body composition, exists for at least in the state of childhood obesity. A short term intervention programme therefore, would down regulate circulating leptin to this threshold value. However, we have no knowledge and idea to interprete the significance of the physiological mechanisms behind this observation in the state of reduced body mass and fat mass. Future studies, therefore, should investigate whether a reduction in circulating leptin with a concomitant change in SAT-Top prone some obese children to a regain in body weight and fat mass or not.

We additionally investigated fat mass (FM_{LIPO}) and subcutaneous adipose tissue volume (SAT-Vol) by means of Lipometer. FM_{LIPO} and SAT-Vol were correlated slightly better with leptin levels than BIA-derived fat mass (FM_{BIA}), both before and after the three weeks (Table 2). The application of BIA might be limited for several reasons [2] and the use of BIA, therefore, seems to be questionable in reflecting the relationship of leptin with changes in body fat mass. Moreover, even the thickness of one body site (*1-neck*) which could serve as a proxy measure of body fatness was associated with leptin more strongly than FM_{BIA}.

In summary, we found a high association of leptin with subcutaneous adipose tissue distribution in obese boys. This association was pronounced with respect to the load of factor 1 (trunk) and factor 2 (extremities) after the intervention. Factor 1 of obese boys is dramatically reduced which suggests that this kind of intervention programme leads to a specific reduction in the thickness of subcutaneous adipose tissue.

The application of the optical device LIPOMETER enables a rapid and safe determination of Subcutaneous Adipose Tissue Topography (SAT-Top). The use of a factor plot seems to be a valid approach to monitor changes in body fat distribution for at least in childhood obesity.

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List of Abbreviations:

BIA	Bioelectrical Impedance Analysis
FM	Body Fat Mass
FM_{BIA}	Total Body Fat Mass, assessed by means of BIA
FM_{LIPO}	Total Body Fat Mass, assessed by means of LIPOMETER
SAT	Subcutaneous Adipose Tissue
SAT-Vol	Subcutaneous Adipose Tissue-Volume, assessed by means of LIPOMETER
SAT-Top	Subcutaneous Adipose Tissue Topography, assessed by means of LIPOMETER
RIA	Radio Immunological Assay
NPY	Neuropeptide Y
m_{1-5}	healthy men of five age decades (20–30yrs, 30–40yrs,...)
w_{1-5}	healthy women of five age decades (20–30yrs, 30–40yrs,...)
w_d	women with Non-Insulin-Dependent Diabetes Mellitus (NIDDM) of the fourth and fifth age decade (50–60yrs, 60–70yrs)

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RELATIONSHIPS BETWEEN PERFORMANCE AND LEPTIN IN FEMALE ROWERS

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ABSTRACT

The aim of the present investigation was to study the possible relationship between performance and leptin in female rowers. Ten college level rowers (19.4±1.6 yrs; 173.4±5.1 cm; 67.7±10.4 kg; body fat%: 27.8±7.8 %) participated in this study. Venous blood samples for the determination of leptin were obtained during the follicular phase of the menstrual cycle in the morning after an overnight fast (11.6±9.4 $ng.ml^{-1}$). Body composition was measured using dual-energy X-ray absorptiometry (Lunar DPX-IQ scanner, Lunar Corporation, Madison, USA), and analyzed for fat (FM) and lean (LM) tissue mass. 2000 metre rowing performance was assessed on a rowing ergometer (Concept II, Morrisville, USA) and maximal oxygen consumption (TrueMax 2400 Metabolic Measurement System, Parvo Medics, USA) during the test was measured. All rowing performance parameters were correlated with plasma leptin ($r>-0.66$; $p<0.037$). Stepwise regression revealed only FM (adj. $R^2=0.731$; $p<0.001$) from body composition and maximal oxygen consumption per kg body mass (adj. $R^2=0.651$; $p<0.003$) from rowing performance parameters as the main determinant for the variation in leptin in female rowers.

It was concluded that relative oxygen consumption during 2000 metre rowing ergometer race, which is also a function of body composition, is the main determinant of leptin variance from performance parameters in female rowers.

Key words: leptin, rowing performance, female rowers

INTRODUCTION

Leptin is the product of the *ob* gene and is secreted from adipose tissue [19]. Leptin is thought to be the missing link between adipose tissue and certain systems regulating body weight and energy expenditure [1]. In trained subjects, circulating leptin is low, and even at biological extreme low levels of body fat mass, plasma leptin concentration is related to body fat content in female [9] and male [17] athletes. In addition, plasma leptin has been reported to be negatively related to aerobic fitness parameters in active females [5]. However, recent findings have also suggested that body fat mass may be reduced in female endurance athletes despite stable plasma leptin concentration [12]. Energy intake and expenditure are of the utmost importance to the competitive athlete in relation to maintaining energy stores with respect to training volume [12] and it is hypothesized that fasting plasma leptin levels could be used to monitor the metabolic state of the organism in female endurance athletes.

To our knowledge, the influence of rowing performance parameters to the resting plasma leptin levels in blood of female athletes has not yet been studied.

The aim of this study was to investigate the possible relationship between fasting plasma leptin with rowing performance parameters in college level female rowers.

MATERIALS AND METHODS

Ten female college level rowers volunteered to participate in the study. They had trained regularly for the last 4.3 ± 0.6 years. Measurements took place at the beginning of competitive period (i.e. in May). The rowers were familiarized with the procedures before providing their written consent to participate in the experiment as approved by the Medical Ethics Committee of the University of Tartu. All subjects were normally cycling and had a menstrual cycle duration of 26–35 days. They were required to have at least three months of documented menstrual cycles, and were not using the oral contraceptive pill for at least six months preceding the study. Venous blood samples were obtained during the follicular phase of the menstrual cycle [18].

A 10 ml blood sample was obtained from an anticubital vein with the participant in the upright position. The plasma was separated and frozen at –20°C for later analysis. Leptin was determined in duplicate by radioimmunoassays (Milenia Biotec GmbH, Germany).

Body composition was measured using dual-energy X-ray absorptiometry. Scans of the whole body were performed on each of the subjects using a Lunar DPX-IQ scanner (Lunar Corporation, Madison, USA) [2] and analyzed for fat (FM) and lean (LM) tissue mass.

Rowers were asked to cover a distance of 2000 metre in the least time possible on a rowing ergometer (Concept II, Morrisville, USA) and the expired gas was sampled continuously for the measurement of maximal oxygen consumption (VO_{2max}; TrueMax 2400 Metabolic Measurement System, Parvo Medics, USA) [11, 14]. Heart rate was recorded during this test using Sporttester Polar Vantage NV (Kempele, Finland).

Means and standard deviations were determined. Spearman correlation coefficients were calculated to determine the strength of the relationship between each measured body composition and rowing performance parameters with plasma leptin values. The independence and significance of variables were tested by stepwise multiple regression analyses based on the results of correlation analysis [17]. For all tests, the level of significance was set at 0.05.

RESULTS

Fasting plasma leptin 11.6±9.4 $ng.ml^{-1}$ was measured in the follicular phase of the menstrual cycle. When body composition parameters were considered (Table 1), the expected relationship between adiposity and plasma leptin was found. Body mass and fat mass parameters were related to plasma leptin ($r>0.71$; $p<0.020$). All rowing performance parameters (Table 2) were also correlated with plasma leptin ($r>-0.66$; $p<0.037$).

Table 1. Body composition characteristics and the relationship with leptin in female rowers (n=10).

Variable	Mean ± SD	Correlation with leptin
Age (yr)	19.4±1.6	r=0.20 (p=0.584)
Height (cm)	173.4±5.1	r=0.04 (p=0.911)
Body mass (kg)	67.7±10.4	r=0.71 (p=0.020)
%FM	27.8±7.8	r=0.87 (p=0.001)
FM (kg)	19.6±7.9	r=0.87 (p=0.001)
LM (kg)	48.1±4.2	r=–0.10 (p=0.784)

Table 2. 2000 metre rowing performance characteristics and the relationship with leptin in female rowers (n=10).

Variable	Mean ± SD	Correlation with leptin
Time (s)	476.3±21.9	r=0.80 (p=0.006)
Power (W)	210.3±25.9	r=–0.76 (p=0.011)
VO_{2max} (l.min^{-1})	3.3±0.4	r=–0.66 (p=0.037)
$VO_{2max/kg}$ (ml.min.$^{-1}$kg^{-1})	49.5±8.3	r=–0.83 (p=0.003)

A stepwise multiple regression analyses were carried out with the plasma leptin concentration as the response variable, and the body composition and rowing performance variables that had shown a significant relationship with plasma leptin as the explanatory variables (Table 3). The first analysis included estimates of body composition and demonstrated that only FM contributed significantly to leptin (adj. R^2=0.731; $p<0.001$). In the next model, rowing performance parameters were used and only $VO_{2max/kg}$, which is also a function of body composition, remained as an independent determinant for leptin (adj. R^2=0.651; $p<0.003$).

Table 3. Multiple regression analysis with leptin (ng.ml^{-1}) as response variable; the regression coefficient (β), the 95% confidence interval (95% CI), and the p-level of significance is shown.

Stepwise Regression Model			
Independent Variables	β	95% CI	p
FM (kg) Intercept: –7.747 adj. R^2=0.731	0.872	±0.950	0.001
$VO_{2max/kg}$ (ml.min^{-1}.kg^{-1}) Intercept: 58.400 adj. R^2=0.651	–0.830	±1.034	0.003

DISCUSSION

It has been reported that leptin may be responsive to the disruption in the balance of energy intake and expenditure [3, 4, 5]. In the present study, the relationship of fasting plasma leptin with body composition and rowing performance parameters was evaluated in college level female rowers at the follicular phase of the menstrual cycle. The relationship between estimates of adiposity and leptin has previously been demonstrated in different endurance athletes [9, 17]. To our knowledge, no studies have yet investigated the influence of plasma leptin concentration to sport-specific performance parameters in female endurance athletes. The subjects of the present study were female rowers as about 86–94% of training volume during the winter and 70–77% in summer has been reported to be extensive endurance training [10]. Furthermore, rowers are characterized by relatively high FM values compared with other endurance athletes [7, 11, 16]. However, a high body mass does not penalize rowers, whose body mass is supported in the boat [14, 16]. Together, the results of the present study demonstrated that in female college level rowers, plasma leptin is highly related to: 1) total FM from the measured body composition parameters; and 2) relative oxygen consumption, which is also linked to body composition, from the measured 2000 metre rowing performance parameters.

The primary finding in the present investigation was that fasting plasma leptin levels in blood were significantly related to performance parameters of a 2000 metre rowing ergometer race (see Table 2). Furthermore, of the measured performance parameters, $VO_{2max/kg}$ remained as a single determinant for leptin (adj. R^2=0.651; p<0.003). It has to be considered that the aerobic energy supply is responsible for about 70–86% of the total energy in 2000 metre rowing race [6, 14]. The results of the present study indicate that athletes with better aerobic energy metabolism during 2000 metre rowing ergometer race have also a lower level of leptin in blood at rest (r=0.80; p=0.006). Accordingly, leptin could be used to assess human metabolic adaptation to endurance training and the lowered resting level of leptin in blood indicates the improved rowing performance in female college level rowers.

In contrast, an increased total FM has been reported to be linked with elevated plasma leptin concentration in females [8, 13]. There appears to be a positive relationship between adiposity indices and fasting plasma leptin in females [18] and total FM also remained the strongest predictor of leptin regardless of other independent determinants in our female rowers (adj. R^2=0.731; p<0.001). In terms of leptin responses to exercise training, a FM loss of 3 kg has been shown to correspond with a decrease in mean fasting plasma leptin of approximately 7 $ng.ml^{-1}$ [8]. However, a significant reduction in total FM by 2 kg was not followed by a concomitant reduction in fasting plasma leptin concentration during intense training period in female swimmers [12]. Therefore, a significant increase in energy expenditure was not followed by a significant increase in energy intake during intense training period [12]. This suggests an alteration of the integration between adiposity and leptin in female endurance athletes. Thus, it appears that energy intake and other adiposity values are not only determinants of fasting plasma leptin concentration in female endurance athletes. Accordingly, although total FM was the strongest predictor of leptin in our female college level rowers, other factors such as an increase in other hormone concentrations [15] and/or increased maximal aerobic energy metabolism (see Table 2) may play an important role in leptin regulation in female endurance athletes. Noland et al. [12] also argued that no further change in leptin concentration with total FM loss in female endurance athletes may function to maintain the decrease in adiposity gained with endurance training. It is, therefore, suggested that leptin could be regarded as a signal for metabolic adaptation to endurance training in female athletes.

In conclusion, the present study showed that circulating plasma leptin is related to specific adiposity and performance parameters in female college level rowers. In addition, metabolic parameters appear to be associated with leptin in sport-specific manner in athletes. The lowered resting level of leptin in blood indicates the improved rowing performance in female college level rowers.

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EXAMINATION OF THE TIME RESPONSE OF THE METAMAX I AND II METABOLIC ANALYSERS AT THE ONSET AND END OF EXERCISE

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ABSTRACT

The time response of the Metamax I and Metamax II metabolic analysers has been examined at the onset and end of exercise. This instrument has a built-in averaging, probably introduced to minimise random variations, that slows the response to sudden changes. The O_2 uptake of moderately trained men was measured simultaneously by the Metamax and by the Douglas bag technique (control method), and the results of the parallel measurements have been compared. The effect of trying to remove the built-in averaging by numerical techniques has also been examined. The O_2 uptake at the onset of exercise rose faster as measured by the Douglas bag technique than that reported by the Metamaxes. Removing the built-in averaging numerically accelerated the response of the Metamaxes and reduced the difference to the results of the control method by around 50%. However, this manipulation introduced artificial fluctuations in the data. At the end of exercise the O_2 uptake reported by the Metamaxes did not fall as fast as that measured by the Douglas bag technique. Removing the built-in averaging numerically had little effect on the difference. It is concluded that O_2 uptake reported by the Metamaxes is delayed, and the true value cannot be fully restored numerically. Numerical manipulation may in addition introduce artificial fluctuations.

Key words: portable oxygen analyser; automatic O_2 analyser; oxygen consumption or oxygen uptake; exercise; time response

INTRODUCTION

Aerobic processes dominate the energy release during most types of exercise, and therefore the O_2 uptake is widely measured to quantify the aerobic energy release during exercise. The body's O_2 uptake was traditionally measured by the Douglas bag technique where typically ≈100 L of expired air was collected in one bag for later analyses. This is a precise method, but it is quite time consuming and thus gives a limited time resolution. The method is also largely restricted to experiments in the laboratory. Electronic sensors that measure the gas fractions and the expired volumes have been available for more than 20 yr, and commercial fully automatic analysers are now available both for use in the laboratory and in the field. To minimise random effects these instruments often report the value averaged over some time. This dampens sudden changes and probably also delays the response of the O_2 uptake at the onset and end of exercise, meaning that transients are not reported accurately. This study examines how the built-in averaging in the portable Metamax metabolic analyser affects its time resolution and its response to sudden changes in the O_2 uptake seen at the onset and at the end of exercise. The effect of removing the averaging by numerical methods is also examined. Subjects have in some experiments suddenly started exercise at a constant intensity. In other experiments they suddenly stopped the exercise. In both cases the O_2 uptake during the first 2 min after the sudden changes has been measured simultaneously by the Metamax and by the Douglas bag technique, the latter being used as the control method.

METHODS

Subjects

Four healthy and moderately trained men 25–46 yr old served as subjects in this study. They were familiarised with exercise testing and the equipment used before any measurements were done. The subjects were in line with national regulations for experiments on human subjects informed that they served as volunteers and that they could leave the study at any stage without giving a reason for doing so.

Experiments

The experiments were carried out either as bicycling on a bicycle ergometer or as running on a treadmill. In some experiments the subjects suddenly started exercise from the resting state and continued to exercise at a constant intensity. In other experiments they exercised at a constant intensity for ≈10 min, thus reaching a steady state O_2 uptake. They then suddenly stopped. The O_2 uptake was measured for at least 2 min after the sudden change. These measurements were done simultaneously by the Douglas bag technique and by one or two Metamaxes. More specifically, the breathing valves of two or three instruments were connected in series by specifically designed adapters, thus allowing simultaneous measurement of the O_2 uptake on the same expired air by two or three instruments. The Metamaxes report the data as averages over 10 s intervals, and the sudden starts and stops were therefore synchronised with the beginning of a new 10 s cycles. Expired air was also collected in Douglas bags in intervals of 10 or 20 s. This air was later analysed for its volume and fractions of O_2 and CO_2.

Equipment

Douglas bag method. The sampling time of expired air collected in the Douglas bags was recorded with stop watches connected to the switch used to start and stop the collection. The fractions of O_2 and CO_2 in both the inspired and the expired air were measured by an S 3A/I analyser with an N-22M zirconium oxide-type O_2 sensor and a CD-3A analyser with a P-61B infrared-type CO_2 sensor, respectively (Applied Electrochemistry, Pittsburgh, PA, USA). The volume of the expired air was measured by an S430-A ventilation measure system with a K520–C521 flow transducer (Applied Electrochemistry) while the air temperature was measured simultaneously. The air pressure was measured to the nearest hectopascal by mercury barometers calibrated against high-precision instruments at the Norwegian Institute of Meteorology. The O_2 uptake was calculated from these measurements as explained in more detail elsewhere [3].

Metamaxes. One Metamax I and two instruments of the type Metamax II (Cortex Biophysic, Leipzig, Germany) have been used in this study. The instruments were calibrated and used according to the manufacturer's instructions and recommendations. Connecting breathing valves in series increase the dead space for the instruments closest to the mouth, and that will introduce a systematic errors in the reading of the instrument. The effect of that error was removed by recalculating the data as explained elsewhere [3].

Calculations

The Metamaxes have two main ways of averaging the data as means of minimising the effect of noise in the signals. First there are built-in averagings in the hardware. The values measured during a 10 s period are averaged; the value obtained for interval n is here called x_n. Then a new average, y_n, is calculated in the hardware as follows (Ralph Henkel, personal communication):

(1) $$y_n = (x_{n-2} + x_{n-1} + x_n) / 3$$

The instrument reports the y_n-s. Thus, the output after interval n is influenced not only by the values measured during the nth 10 s period but also by the last two ones before that. The x-s are not readily available. It was therefore tried to recover those data by numeric techniques as explained in the appendix. The equations (A7) and (A9b) obtained were implemented in a spreadsheet.

There are in addition optional averaging in the software that may be switched on or off by the user when the data are analysed. That optional averaging has not been used in this study. Thus, only the minimum averaging that cannot be turned off has been used in all experiments.

The Metamaxes report systematically too large values of the O_2 uptake. That error may perhaps influence the analysis carried out in this study. Therefore new data from the Metamaxes were calculated by correcting for the systematic error. For example, if the data from the Metamax during steady state conditions were 5% larger than those measured by the Douglas bag technique, the results from the Metamax were divided by 1.05.

RESULTS

The reported O_2 uptake rose at the onset of exercise, and the values measured by the Douglas bag technique rose faster than the values reported by the Metamaxes (**Fig. 1**). Removing the built-in averaging of the Metamax numerically (deaveraging) reduced the difference between the two sets of data by ≈50%. The deaveraged values quite often showed fluctuations after 60–90 s, and that effect often grew by time (not shown). The accumulated O_2 uptake reported at a given time point after the onset of exercise was less for the Metamax than that given by the Douglas bag technique (Fig. 1b). Removing the built-in averaging reduced that difference by ≈50%. Even after removing the averaging there was a difference reaching a maximum of ≈0.2 mmol kg^{-1} body mass after 60–90 s. The deaveraged curve of the accumulated O_2 did not show significant fluctuations.

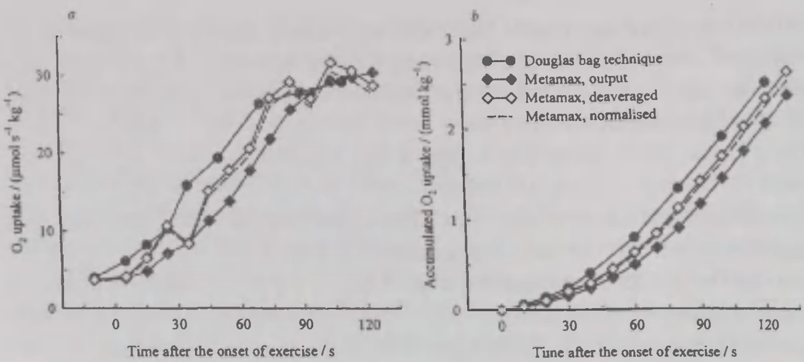

Figure 1. *a*, the oxygen uptake at the onset of exercise measured on subject JTT by the Douglas bag technique and by the Metamax I. The built-in averaging of the Metamax has also been removed by numeric techniques (deaveraging). Finally, the results from this instrument is given after correcting for a systematic error (normalised). The fluctuations for the deaveraged values seen here after 30–40 s were usually not seen during the first minute but usually seen within 90 s. *b* shows the accumulated O_2 uptake for the same set of data.

The O_2 uptake fell when the exercise was suddenly stopped, and the values measured by the Douglas bag technique fell faster than those reported by the Metamax (**Fig. 2A**). Removing the averaging in the values from the Metamax reduced the difference between the two systems only slightly. The accumulated O_2 uptake reported by the Metamaxes was larger than that measured by the Douglas bag technique (Fig. 2B). Removing the averaging did not reduce the difference much in relative terms, usually leaving a difference of more than 0.6 mmol kg^{-1} within 1 min after the end of the exercise.

The Metamaxes report a systematically too high O_2 uptake (see [3] for details). To see how that affects the results, the output from the Metamaxes was corrected for the systematic error. At the onset of exercise the normalised value of the O_2 uptake reported by the Metamax followed that of the Douglas bag technique almost as well as when not correcting for the systematic error (see the dashed curves in Fig. 1). Correcting for a systematic error between the two methods after exercise reduced the difference between the outputs by 10–30% (Fig. 2). Thus, the different responses seen at the onset and the end of exercise could only partly be explained by the fact that the Metamaxes report a systematically too large result.

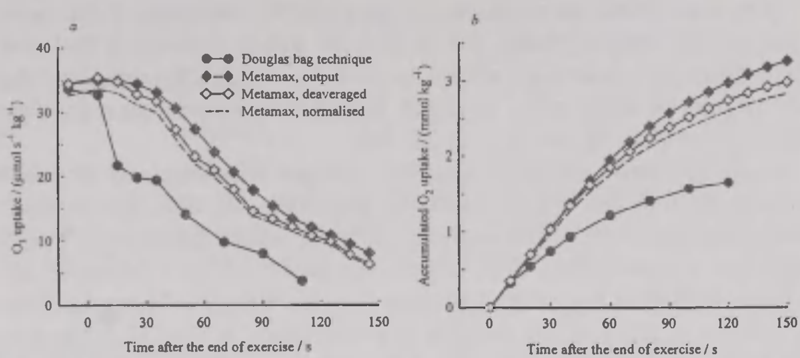

Figure 2. *a*, the oxygen uptake at the end of exercise measured on subject BW by the Douglas bag technique and by the Metamax II. The built-in averaging of the Metamax has also been removed by numeric techniques (deaveraging). Finally, the results from this instrument is given after correcting for a systematic error (normalised). *b* shows the accumulated O_2 uptake for the same set of data.

DISCUSSION

The main result in this study is that the commercial instruments Metamax I and Metamax II have a built-in averaging that delays the response of the O_2 uptake at the onset and end of exercise. Numeric techniques reduced the problem considerably at the onset of exercise, while at the end of exercise a large difference remained between the output of the Metamaxes and that of the control method. Removing the averaging numerically introduced artificial fluctuations in the output after around 1 min.

The built-in averaging will delay the response of the Metamax instruments. According to equation [1] that delay should be no more than 20 s. However, when comparing the results with the measurements by the Douglas bag technique, the delay may apparently be as much as 30–60 s. The reason for this large delay is not known.

Since the mathematics of the built-in averaging is known, it should in principle be possible to recalculate the original, unaveraged values x_n-s as explained in the appendix. That remedy reduced the delay only partly. This suggests that there are other causes of the delay in addition to the averaging according to [1]. Moreover, removing the averaging introduced fluctuations in the readings, usually seen after 60–90 s and thereafter sometimes increasing by time. As explained in the appendix, this effect was not unexpected.

The fluctuations are caused by random effects. Therefore, if the mean from several subjects is used, the fluctuations will be reduced. In that case the deaveraged values may perhaps be used for ≈2 min. Nevertheless, the deaveraging outlined in the appendix should be used with great caution. Further examinations may also be needed.

Fully automatic metabolic analysers are probably designed for long-lasting measurements, and fast time responses are then not needed. During shortlasting exercise or during exercise where the intensity varies suddenly, measurements with a time resolution of 10 s or better are needed. During steady state conditions the data from the Metamaxes are as reliable as those of the Douglas bag technique, at least if day-to-day variations are avoided [3]. Moreover, the fluctuations in the output between consecutive 10 s measurements by the Metamaxes are no larger than those of the Vmax 29 from Sensormedics reported as averages over 30 s intervals (unpublished data from [3]). These observations suggest that technical quality of the Metamax instruments is so good that the built-in averaging in the hardware may not be needed. Future versions of the instrument should allow the user to measure the O_2 uptake with less delay and with better time resolution. Averaging over time should perhaps be restricted to an option in the software that can be turned off, at least by expert users.

Our data suggest that even when the built-in averaging was removed numerically, the output of the Metamax lagged behind that of the Douglas bag technique for 1–2 min after a sudden change. That is not acceptable for precise measurements during shortlasting exercise. For example, when the accumulated O_2 deficit is taken as a measure of the anaerobic energy release, one needs accurate measurements of the O_2 uptake from the start of the exercise [2]. The Metamaxes examined here cannot be used for such measurements unless some systematic errors are accepted. It is conceivable that this problem is not restricted to the Metamax analysers but may be present for most fully automatic analysers using averaging. More specifically. surprisingly large values for the accumulated O_2 deficit has been found when the O_2 uptake has been measured by a fully automatic analyser (unpublished observations). Interestingly, the problem of a delayed response of the instrument appears to be unknown even among experienced users. One reason may be that the problem does not seem to be well addressed in the instruments' manuals.

To sum up, the output of the Metamaxes lags behind the true value during transients. The effect can only partly be removed by numeric techniques, and these techniques introduce artificial fluctuations in the signals that restrict their use further.

APPENDIX

In matrix terms (1) gives

(A1) $y = Ax/3$

where A for the present case is a tridiagonal, lower triangular matrix, that is with 1-s on the main diagonal and the first two subdiagonals (lower left diagonals) while the rest of elements in A are all zero ($a_{ij} = 1$ for $j - 2 \leq i \leq j$, while $a_{ij} = 0$ otherwise). To solve (A1) for $\boldsymbol{x}$, first set $\boldsymbol{z} = \boldsymbol{x}/3$, giving the system

(A2) $y = Az$

In component form (A2) gives

(A3) $y_n = z_{n-2} + z_{n-1} + z_n$

A is a regular (nonsingular) matrix, and solving (A2) for z gives

(A4) $z = A^{-1}y$

(A4) is readily solved by naiv Gauss elimination (since A is lower triangular, only the forward substitution is needed [1]). Assume that this system is solved up to z_{n-1}. Then the next step is to solve z_n, and by inspecting A it is readily seen that (A3) gives

(A5) $z_n = y_n - z_{n-1} - z_{n-2}$

Note that the Metamaxes start with all values set to zero, and that means that $y_n = x_n = 0$ for $n \leq 0$. Therefore also define $z_n = 0$ for $n \leq 0$. It is then immediately seen that $z_1 = y_1$, that $z_2 = y_2 - y_1 = y_2 - z_1$ and that $z_3 = y_3 - y_2 = y_3 - z_2 - z_1$. It follows that (A5) holds for all z_n, also for $n \leq 2$.

Now take the x-s as

(A6) $\boldsymbol{x} = 3A^{-1}y = 3z$

On component form (A6) gives

(A7) $x_n = 3z_n = 3(y_n - z_{n-1} - z_{n-2}) = 3y_n - x_{n-1} - x_{n-2}$

This equation is readily programmed, for example in a spreadsheet, using the data output from the Metamax as the y_i-s.

The built-in averaging of the Metamaxes expressed by (1) is carried out on the measured parameters (f. ex. lung ventilation, fractions of O_2 and CO_2) and not on the on the calculated values (f. ex. O_2 uptake; Henkel, personal communication). Consequently, when the averaging was removed numerically, that should have been done on the measured parameters and not on the O_2 uptake, and the O_2 uptake should be calculated from the deaveraged parameters. That would complicate the calculations, and it would probably not add much. First, the reported O_2 uptake changed proportionally to the lung ventilation for 30–60 s after the sudden changes. In addition, as explained in more detail elsewhere, it is not known how the Metamaxes calculate the O_2 uptake from the measured parameters [3].

Lack of numerical robustness

The matrix *A* is not diagonally dominant. In terms of common matrix theory and solving systems of linear equations by Gaussian eleimination, the absolute value of the multipliers used is exactly 1.00. This makes the solutions less stable numerically, meaning that small errors in the input data may have some influence on the calculated result and contribute to the propagation of errors [1]. It may therefore be instructive to look at expressions for the z_n-s and x_n-s as a function of the reported y_n-s only. Plugging into (A7), one has

(A8a) $x_n = 3z_n = 3(y_n - y_{n-1} + y_{n-3} - y_{n-4} + y_{n-6} - y_{n-7} \ldots)$

or

(A8b) $x_n = 3 \sum^{n}_{i=1} k_i y_i$

where $k_n, k_{n-3}, k_{n-6}, \ldots = 1$; $k_{n-1}, k_{n-4}, k_{n-7}, \ldots = -1$; and $k_{n-2}, k_{n-5}, k_{n-8}, \ldots = 0$. Thus z_n can be expressed as an alternating sum of two out of three of all the y_i-s from $i = 1, .. , n$. This means that if there is an error or some kind of noise affecting one reported y_i, it will influence two out of three calculated z_j-s for $j \geq i$ for ever and thus not die out by time. Several random effects may add up and thus make the calculated *x*-s noisier by time.

It may therefore be useful to work out another approach that may still give the unaveraged data but that is not influenced by noise several minutes ahead. At rest and during exercise of moderate, constant intensity the O_2 uptake reaches a constant value within some minutes. Thus, using the terminology above, for the reported O_2-uptake $y_n = y_{n-1} = y_{n-2}$ apart from possible small random variations. x_n may therefore be taken as

(A9a) $x_n = 3y_n - 2x^*$

or as

(A9b) $x_n = 2y_n - x^*$

where x^* is the constant O_2-uptake up to but not including interval *n*. Now if a sudden change in the O_2-uptake is introduced at the beginning of that interval, for example at the onset of exercise or at the end of exercise, (A9a) or (A9b) may be used to calculate the O_2-uptake for the first and second intervals after the change was introduced. This approach is only minimally influenced by possible noise in a measurement minutes ahead.

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AN IMPACT OF COGNITIVE PROCESSES ON SCHOOL CHILDREN PHYSICAL ACTIVITY INTENTION: A STRUCTURAL EQUATION MODELLING

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ABSTRACT

The main purpose of the study was to investigate by structural equation modeling how students' cognitive processes in physical education lessons are related with physical activity intention. The subjects of this study were 944 schoolchildren (504 girls. 440 boys) at the age of 12 to 18 from eleven different schools in Estonia. Students cognitive processes were assessed by the Cognitive Processes Questionnaire in Physical Education (CPQPE) (Solmon and Lee, 1997). Four items were developed to measure students´ physical activity intentions. The goodness of fit index (0.86) and root mean square residual (0.06) for CPQPE and for items of intention (GFI 0.98, RMR 0.02) were established by confirmatory factor analysis. Structural equation model indicated an importance of self-regulation and willingness to engage in forming of physical activity intention.

Key words: cognitive processes, physical activity, children

INTRODUCTION

Researchers in educational settings now acknowledge that for better understanding the multifaceted process of teaching and learning is insufficient to examine only the variables related to teacher behavior and student achievement, but also the students' thoughts about it. Several researchers have used mediating process paradigm of Doyle [8] as a framework to students' cognitive processes and the relationship of these processes to students' outcomes in learning. Cognitive processes are defined by Wittrock [22] as students' thoughts or cognitions that impact learning, including their beliefs, perceptions, expectations, levels of motivation, and use of strategies. Using questionnaires and interviews as indicants of students' thoughts, Peterson et al. [18, 19] concluded that students reports of their thoughts were more accurate predictors of student achievement than observer estimates of time on task. Solmon and Lee [21] developed the Cognitive Processes Questionnaire in Physical Education (CPQPE) for measuring cognitive variables that impact achievement. The 5–factor structure that emerged in an exploratory factor analysis produced an acceptable fit with the data in the confirmatory factor analysis. This questionnaire consists of five subscales to measure self-regulation, confidence-efficacy, attention-concentration, willingness to engage and use of strategies. The authors found that the subscales of the CPQPE were related to the task-involved goal perspective and the belief that success is attributed to motivation and effort. However, the psychometric properties of the CPQPE have not tested in different cultural context. Therefore, we found that it is important to investigate Estonian students cognitive processes in physical education lessons and to study which part of these processes impact the intention of physical activity. Whereas the promotion of lifetime activity is a major goal of physical education [9] then the students' intention to participate in physical activity during the school time or after the graduation may be viewed also as the outcome of teaching learning process.

Intentions are the immediate and sole determinant of behavior and the determinants of it are one's attitude about performing the exercise actions and the influence of normative social forces on the individual performing in physical activities [7]. Physical activity in youth is an important public health issue, and regular participation in physical activity for young people can enhance their physical, psychological, and social-well beings [5]. Many determinants influence physical activity, but one of the main factor is students' attitude toward physical activity. Attitude influences whether they do or continue physical activity outside from physical education lessons. Promoting good attitudes toward physical education and physical activity is an important component in promoting an active lifestyle among youth. Mummery et al. [15] indicated that when a child or youth holds a positive attitude toward physical activity, perceives significant others believe he or she should participate in physical activity, and feels that he or she has the requisite ability to participate, that individual will form a strong intention. Most studies to research attitude are based on theories of reasoned action [1] and planned behavior [2]. This theory proposes that intention is an immediate determinant of behavior and attitude had a large effect on intention. It means that promoting positive attitudes toward physical education and physical activity gives more opportunities to increase students' intentions to be physically active after graduation. Godin and Shepard [10] have suggested that physical activity during childhood is vital for developing the positive attitudes that make such activities enjoyable, and to sustaining active lifestyles during adulthood. Studies have shown that past behavior in regression analyses to predict physical activity intentions results in the extinction of the influence of attitude, subjective norm and perceived behavioral control on intention [16]. It is now generally recognized that attitudes are relevant for understanding and predicting behavior [3], but there is insufficient information how reliability and validity of attitude measures were established [10]. Despite of many attitude related researches, information on the reliability and validity of an instrument is not provided makes the worth of the data questioned. In many ways it is important to investigate students´ attitudes and their intentions toward physical activity, and in this research a seven new questions were developed to measure students´ physical activity intentions.

Review of the literature allows to hypothesise that cognitive processes have a significant role on physical activity intention. According to the past behavior it is hypothetically possible to predict the students´ behavior and their intentions to be active after graduation. The purpose of the study were to:

1. validate an Estonian version of CPQPE by attempting to reproduce its factor structure utilizing both exploratory and confirmatory factor analyses;
2. develop new items for measuring students' physical activity intention; and
3. investigate by structural equation modeling how students' cognitive processes in physical education lessons are related with physical activity intention.

METHOD

Participants

The subjects of this study were 944 schoolchildren (504 girls and 440 boys) at the age of 12 to 18 from 11 different schools in Estonia. The students filled the questionnaire in the class-teacher lessons and before implementation they got an exact introduction. Children were confirmed that their answers would remain confidential and the questionnaires will only be used by researchers. The permission to carry out the study was obtained from the headmaster of the school and the class-teacher. Before the main research, the control test was carried out to confirm the understanding of the questions. First, a small group (13 students) read through the questions and after that the researcher read the questions loudly, asking whether or not they understood the items.

The listwise deletion was used to remove the missing values from data set. After that, the responses to questionnaire of 924 students were subjected to data analyses.

Instrumentation

The students cognitive processes were assessed by the responses to the Cognitive Processes Questionnaire in Physical Education (CPQPE) developed by Solmon and Lee [21]. To assess students´ physical activity intention seven new items were developed. Additionally to these scales two questions at the beginning of the questionnaire about the students´ physical activity were asked (Are you physically active in your leisure time. If yes, how many times a week are you doing sport outside from the physical education lessons).

Cognitive Processes

The CPQPE is a 33-item scale consisting 5 different subscales (self-regulation, confidence-efficacy, attention-concentration, willingness to engage, strategies) to measure cognitive processes. Each item is rated on a five-point Likert-type scale from 5 (strongly agree) to 1 (strongly disagree).

Intention

Seven new items were developed to measure physical activity intention among schoolchildren. These items were developed from several sources and the content of validity of the items were evaluated by the two internationally acknowledged sport psychologists. They indicated on three of the question with which some problems may appear. In choosing the items, the researchers based on the studies of theories of reasoned action and planned behavior, where the results indicated the strong relation between attitude and intention [3, 12, 13]. Attitude research suggests that positive intentions are important determinants of children's decision making for physical activity and that such intention is determined by attitudes [4]. In the pilot study the researcher read the questions loudly and the students discussed what the item meant and whether they understood it. The questionnaire was five-point Likert scale, where students had to indicate their level of agreement with statements (from strongly disagree to strongly agree).

The construct validity of the instrument was assessed through factor analysis (exploratory and confirmatory factor analysis). Internal consistency on subscale on the data collected for this study was assessed using coefficient alpha [6].

Data analysis

The internal consistency of the questionnaire subscales and factor analysis of the instruments were analyzed by the statistical package STATISTICA. The construct validity of the subscales of cognitive processes and seven intention items was tested with confirmatory factor analysis using LISREL 8.51. Using LISREL 8.51 a structural equation modeling procedures were used to test the relationships between dimensions of cognitive processes and the items of intention.

RESULTS

CPQPE

Validity of the instruments was assessed through exploratory (EFA) and confirmatory factor analysis (CFA). For the factor analyze data of 924 students was randomly split to produce two subsamples, one for EFA (n=462) and the other for CFA (n=462). In EFA a five-factor solution was emerged as it was in the original data. Factor loadings for each of the items were 0.40, but some of the items were excluded from the further analyze. Items 1, 2 and 10 from self-regulation and item 5 from the factor of attention-concentration were excluded, as they did not meet the criteria of loading on one factor. The items of the subscales are presented in appendix. The results of the EFA are presented in the Table 1. Internal reliability of the subscales was assessed through Cronbach alpha coefficient. After reliability test three items of the confidence-efficacy (item 4, 5, 7) were excluded from the further analyses as they showed low reliabilities (0.47). Cronbach alpha coefficients for the subscales of the CPQE after exclusion of the items were: self-regulation 0.79, confidence-efficacy 0.62, attention-concentration 0.75, willingness to engage 0.78, use of strategies 0.78.

Table 1. Factor pattern loadings from exploratory factor analysis of CPQPE.

Dimension	Items	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Self-regulation	S3				0.557	
	S4				0.704	
	S5				0.671	
	S6				0.650	
	S7				0.618	
	S8				0.563	
	S9				0.482	
Confi-denceefficacy	C1	0.672				
	C2	0.611				
	C3	0.695				
	C6	0.441				
Attention-concentration	A1			0.758		
	A2			0.765		
	A3			0.470		
	A4			0.744		
	A6			0.529		
Willingness to engage	E1					0.722
	E2					0.506
	E3					0.747
	E4					0.769
	E5					0.493
Use of strategies	ST1		0.765			
	ST2		0.682			
	ST3		0.701			
	ST4		0.612			
	ST5		0.786			

Note: see the labels in Appendix 1.

The factor structure and the model fit of the CPQE were tested by the confirmatory factor analysis (CFA). The results of the confirmatory factor analyses confirmed the fit of the model and CFA indexes of fit were similar to data reported by Solmon & Lee [21]. The indexes of fit from the CFA are presented in Table 2.

Table 2. Confirmatory factor analysis indexes of fit of CPQPE

	This study	Solmon and Lee [21]
Goodness-of-fit index	0.86	0.86
Adjusted goodness-of-fit index	0.83	0.84
Root mean square residual	0.06	0.06

*p<.001.

Instrument for Intention

To assess the relation of students' cognitive processes and students' physical activity intention, seven items were developed. Reliability and validity of the instrument are key components in quantitative measures of attitude and intention [20]. Three of the items were excluded from the further analyses as they showed low reliabilities (under 0.60, the closer the reliability coefficient is to 1.00, the more reliable the scores on the instrument). The exclusion of these items confirmed the opinion of two sport psychology experts about the content validity of the items. The Cronbach alpha after exclusion of three items was 0.81. The items which revealed a good reliability were: 1) I am interested in developing my physical fitness, 2) Outside from the physical education lessons I like to do sport, 3) After graduation I would like to take part of the sport club trainings, 4) After graduation I would like to be physically active.

As the reliability coefficient is not enough to confirm does the item really measure what it is supposed to measure, the validity of the items was measured through factor analysis. For the factor analyses, total data of 924 students was randomly split to produce two subsamples, one for EFA (n=462) and the other for CFA (n=462). The results of the exploratory factor analyses showed that all four items loaded on one factor and indicated that items designed to measure attitude. The results from the varimax and oblique rotation were similar and the minimal loading of 0.40 was used in the interpretation of these factors. The results of the EFA are reported in Table 3.

Using the LISREL 8.51 statistical package the results of the confirmatory factor analysis showed that the factor obtained through EFA fit the model. The asymptomatic covariance matrix was used as data input and maximum likelihood method of estimation was chosen. It indicated that each item loaded on one factor as it emerged in an EFA. So only one latent construct was formed (intention). The standardized factor loadings and the error variances are presented in Figure 1. To standardize the latent variable, the variance of a factor has fixed to equal a constant (1.0). Fixing the variance of a factor to 1.0 has an advantage of simplicity. The factor loadings of the items were all statistically significant (standardized estimates: Item 1 = 0.75; Item 2 = 0.88; Item 3 = 0.81; Item 4 = 0.79; $p<0.001$). Measurement error in CFA model can be seen as unmeasured exogenous variables, so 44% of item 4, 23% of item 5, 35% of item 6 and 35% of item 6 variance is unexplained. Strong factor loadings and the satisfactory measurement errors of the items suggest a conclusion regarding the fit of the four new items.

Table 3. Factor pattern loadings from exploratory factor analysis of physical activity intention.

Items of physical activity intention	Factor loadings
1. I am interested in developing my physical fitness.	0.781
2. Outside from the physical education lessons I like to do sport.	0.867
3. After graduation I would like to take part of the sport club training.	0.820
4. After graduation I would like to be physically active.	0.813

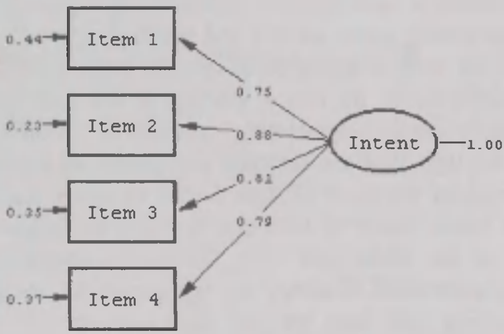

Figure 1. Confirmatory factor analysis model for physical activity intention.

Goodness of fit was assessed by examining the Comparative Fit Index (CFI), Normed Fit Index (NFI), adjusted goodness-of-fit (AGFI), goodness-of-fit (GFI), root-mean-square residual (RMR). The CFI, NFI, are members of the class of incremental fit indexes that compare the fit of a restricted model to a baseline model, usually the null model [14]. For these indexes, minimum values of 0.90 generally are considered to represent an acceptable fit. Values for the GFI, AGFI indexes range from zero to 1, with values closer to one indicating a better model fit. Lower values (from zero to 1) for the RMSR indicate a better fit. The indexes of fit from the CFA are presented in Table 4 (Model 1). Table 4 shows that the values for the incremental fit suggesting a good fit of the model. In this study were not used chi-square and chi-square to degrees-of-freedom ratio to assess the fit of the model. In the past these indexes were widely used, but it is now recognized that these indexes are not good measures of model because of the sensitivity of the chi square statistic to sample size.

A structural equation modeling of students' cognitive processes and their physical activity intention

The main idea of structural modeling was to examine which part of the cognitive processes impact students' intention most. Three models were formed: one for the total sample, second with the students, who were making sport over one time week outside from the physical education lessons and the third, who were not. The variance-covariance matrix was used as data input and maximum likelihood method and the different indexes of goodness-of-fit were used to estimate the fit of the model. The analyses were conducted on the total sample (n=924) and the results of the structural equation modeling are presented in Figure 2. Large circles in the figure represent latent factors and rectangles are inventory items. As in Figure 2 an item is specified to load on only a single factor, then standardized estimate of its factor loading is also correlation and the square of its factor loading equals the proportion of variance explained by the factor. So the item 3 of the subscale willingness to engage and item 1 of strategies explain the most of their factor variance, accordingly 74% and 67%. The latent factor of intention is specified to load on multiple factors (four of its items and five factors of cognitive processes), however, its standardized loadings are interpreted as standardized regression coefficients (i.e., beta weights) that take account of the correlations between these five factors, what this indicator supposed to measure. Accordingly to this model the best predictors of the physical activity intention are self-regulation and willingness to engage. However, inspection of the values of the fit indexes indicated an acceptable fit of the model. The goodness of fit indexes are presented in the Table 4 (Model 2).

Table 4. Goodness-of-fit indexes for the estimated models.

Goodness of fit indexes Models	NFI	CFI	AGFI	GFI	RMR
Model 1: CFA	0.98	0.98	0.90	0.98	0.02
Model 2: Total	0.91	0.91	0.95	0.94	0.05
Model 3: PA	0.90	0.91	0.93	0.94	0.04
Model 4: NPA	0.91	0.90	0.91	0.94	0.04

Note: Model 1- goodness-of-fit indexes of the confirmatory factor analyses of intention; Model 2: goodness-of-fit indexes of structural equation modeling of students cognitive processes and intentions; Model 3- PA- physically active students; Model 4- NPA- not physically active students.

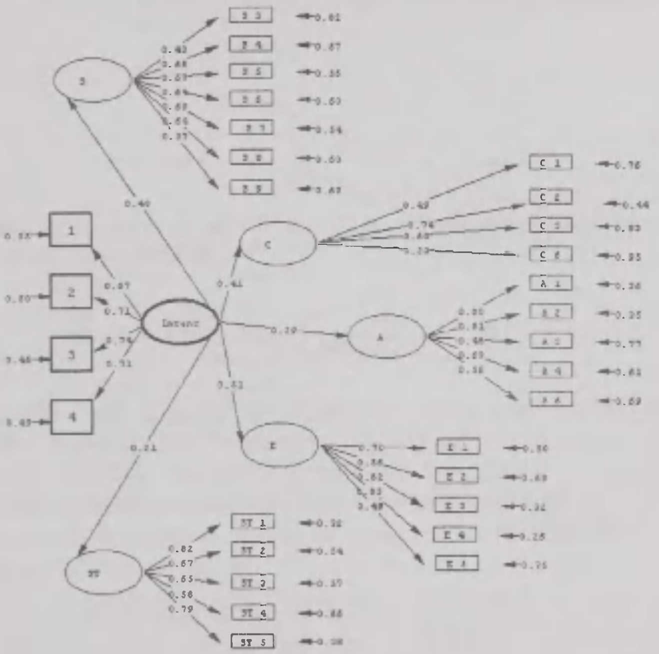

Figure 2. Structural model of students' cognitive processes and physical activity intention.

Two other structural models were formed to investigate the differences between the cognitions of these students, who are physically active outside from physical education lessons more than one time a week and those who are not. The second analysis was conducted with the sample of students (n=598) who are doing sport outside from the sport lessons. The model with regression coefficients and measurement errors are presented in Figure 3 and the indexes of fit (Table 4, Model 3) indicated an adequate fit of the hypothesized model. Willingness to engage (standardized coefficient=0.56, $p<0.01$) and self-regulation (standardized coefficient=0.55, $p<0.01$) were the best predictors of the intention. Also confidence-efficacy and attention-concentration explain 38% of the variance of physical activity intentions. The data analyze with those students who were physically active outside from the PE lessons showed that the effect of use of strategies on intention changed to minimum (0.10).

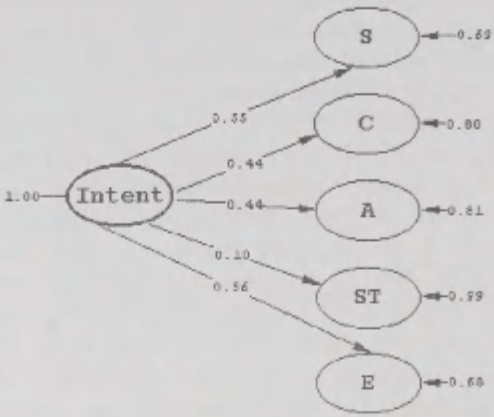

Figure 3. Structural model of physically active students´ cognitive processes and physical activity intention.

Third model was formed to examine which part of the cognitive processes impact those students' intentions most who are not physically active in their leisure time. A structural equation model diagram of this model is shown in Figure 4. The sample size of this analyze was 326 students' who indicated that they were doing sport only in the physical education lessons. Goodness-of-fit indexes showed the fit of the model (Table 4, Model 4). In this model all five independent variables predicted the physical activity intention quite equal. As it was in the two first models the best predictors of intentions were self-regulation (standardized coefficient=0.42, p<0.01) and willingness to engage (standardized coefficient=0.34, p<0.01). But in this model the use of strategies indicated for greater amount of variance (standardized coefficient=0.31, p<0.01) in intentions. Confidence-efficacy and attention-concentration accounted for 45% of the variance of intentions.

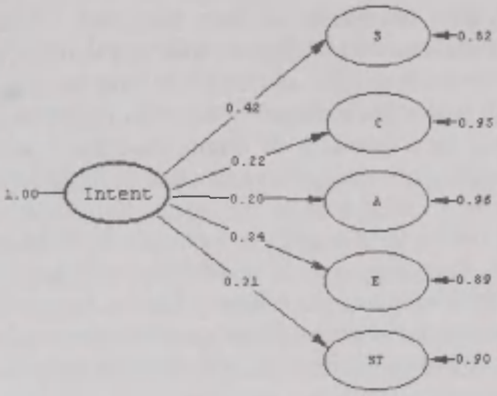

Figure 4. Structural model of not physically active students' cognitive processes and physical activity intention.

DISCUSSION

This study was designed to determine which part of the students' cognitive processes influences their physical activity intention the most. Structural equation modeling procedures were used to evaluate the hypothesized structural relationships between students' cognitive processes and their physical activity intention. After exclusion of three of confidence-efficacy items (4, 5, 7) reliability test for CPQPE indicated the fit of the questionnaire. After exploratory factor analyses three items of self-regulation were eliminated, as two of them didn't emerged in their factor and the factor loading of tenth questions (When I make mistakes during practice, I say to myself "I can do better") stayed under 0.40. However, analyzing the two first questions (I find that new games and skills are fun once you give them a try; I like to learn new and different games and skills), can suggest that they estimate more the enjoyment of physical activity than the self-regulation. Also the fifth item from attention-concentration (When I am practicing, I try to think only about the skill I am working on) eliminated from subsequent analysis, because it emerged in another factor. After exclusion of these items, the five-factor solution emerged as it was in original data by Solmon and Lee [21]. Also CFA indicated the fit of the model confirming the five-factor structure of the instrument.

Seven new items were designed to measure the physical activity intention. Based on the theory of planned behavior and reasoned action the items were formed. Low reliabilities of three items did not allow their inclusion in subsequent analyses. However, four of the items showed a good reliability (0.81) and both EFA and CFA indicated the acceptable fit of the questions. All four items emerged in one factor with strong factor loadings (over 0.70). Two questions of fourth, measure direct physical activity intention, as they ask about the plans after graduation (After graduation I would like to take part of the sport club trainings, After graduation I would like to be physically active). Other two questions are related to intentions (I'm interested in developing my physical fitness, Outside from the physical education lessons I like to do sport), as they measure the attitude toward physical activity at the present moment and strong attitudes are said to be relatively stable over time, to be resistant to persuasion, and to predict manifest behavior [3].

Structural equation modeling procedures were used to evaluate about hypothesized structural relationships between students' cognitive processes and their physical activity intention and which part of the students' cognitive processes impact the students' intention most. At first the total sample was used. The results of the structural equation model indicated that willingness to engage (standardized coefficient=0.51), self-regulation (standardized coefficient=0.48) and confidence-efficacy (standardized coefficient=0.41) are the best predictors of intention. However, using of strategies and attention-concentration explain also 13% of the variance of intention.

Based on the assumption that frequent performance of a behavior leads to the formation of habit, and that habits can influence behavior independent of attitudes and intentions, theorists have proposed that frequency of past behavior be added to the theory of planned behavior and reasoned action model [17]. However, the studies have revealed a significant interaction between intention and past behavior. So the other model was formed, to estimate, which part of the cognitive processes impact the students´ who are physically active anyway. The results indicated again the great importance of willingness to engage (standardized coefficient=0.56) and self-regulation (standardized coefficient=0.55). Also confidence-efficacy and attention-concentration explain 38% of the variance of physical activity intentions. The results showed no relation between using of strategies and physical activity intention.

The third model was formed with the sample of not physically active students. The results indicated the importance of all parts of the cognitive processes. The best predictor of intention was self-regulation (standardized coefficient=0.42), beyond willingness to engage (standardized coefficient=0.34) and the use of strategies (standardized coefficient=0.31). Confidence-efficacy and attention-concentration accounted for 45% of the variance of intentions. Intentions are supposed to reflect the relative strength of an individuals motivation to engage in the behavior [3].

The results of the structural equation modeling allows to assume that teachers of physical education who emphasize the willingness to engage and self-regulation in teaching process, can enhance students' physical activity intention. The use of strategies is not important for those students who are doing sport outside from the physical education lessons, but for students who are not, it is important to emphasize this part of the cognitive processes. According to the results the following conclusions can be made:

1. The Cognitive Processes Questionnaire in Physical Education is a reliable tool to measure students' cognitive variables in physical education in another cultural context;
2. Four new items to measure students' physical activity intention indicated a good reliability and validity, what allowed using these items for measuring intention; and
3. Structural equation model indicated an importance of self-regulation and willingness to engage in forming of physical activity intention.

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APPENDIX

Self-Regulation (S)
1. I find that new games and skills are fun once you give them a try.
2. I like to learn new and different games and skills.
3. I feel like I can do well if I try hard.
4. When I practice a skill, I try to figure out.
5. If I am good in practice, I keep trying hard what I am doing wrong.
6. I try to remember the important things the teacher says about a skill when I am practicing.
7. When I am practicing skills in PE class, I try to get better each time.
8. I work hard during practice in PE class.
9. If I don't understand how or what to do I ask the teacher for help.
10. When I make mistakes during practice, I say to myself "I can do better“.

Confidence-Efficacy (C)
1. It is hard to me to correct the things the teacher says I was doing wrong.
2. During PE class I give up when the skill is hard.
3. When I cannot do a skill in PE, it is because it is too hard.
4. When the teacher tells me what I am doing wrong I do not understand it.
5. When I can do a new skill in PE, I think it is because I am lucky.
6. I feel bad when my skills are not as good as my classmates.
7. When I listen and watch the teacher explain a skill, I think "Oh, I can do that“.

Attention-Concentration (A)
1. When the teacher is talking, I find myself thinking about other things.
2. During class, I talk my friends when I should be practicing.
3. I listen closely when the teacher explains a skill during the PE lesson.
4. I miss the important things the PE teacher says because I am not paying attention.
5. When I am practice, I try to think only about the skill I am working on.
6. I only try hard when the teacher is looking at me.

Willingness to Engage (E)
1. I would rather stay in the classroom than go to PE class.
2. I feel like I can't do well no matter how hard I try.
3. In PE class I try to stay in the back of the line so that I won't have to take as many turns.

4. I only like to do games and activities that I am good at.
5. I avoid practicing any way I can.

Use of Strategies (ST)

1. I try to go over the right way to perform the skill I learn in PE in my mind at home.
2. When I practicing a skill, I try to think how it is like something I already know.
3. I talk to myself during practice to help me do better.
4. When the teacher explains a skill, I practice the skill in my mind.
5. I try to practice skills I learn in PE class at home.

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COMPARATIVE EVALUATION OF THE INFLUENCE OF SMALL GAME 4 VS 4 AND RUNNING LOAD IN THE TRAINING OF YOUNG FOOTBALL PLAYERS

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ABSTRACT

The aim of the study was to provide a comparative evaluation of the influence of complex loads (game + run + game) on the young football players' aerobic capacity. The subjects were 8 young male football players, mean age 18.5±2.0 yrs, height 177.5±5.1 cm, weight 71.3±5.9 kg. The load consisted of 8 min intensive small game 4 *vs* 4 on a grass court of 20x30 m. This was followed by 8 min running load while heart rate (HR) was kept in the bracket of 170–180 beats·min^{-1} and again a small game of 8 min. Tests were separated by 3 min intervals of passive recovery. During the whole test HR was measured continuously with Polar Vantage sport tester. Blood lactate (BLA) concentration was determined enzymatically with Lange analyser. Perceived exertion and perceived readiness ratings were evaluated by Borg [6] and Karu et al. [9], respectively. Study results showed that intensive small game is too intense for influencing aerobic capacity of a young football players. As to metabolic shifts, more favourable indices occurred during the 8 min running load with HR 170–180 beats·min^{-1}. We can conclude that intensive small game 4 *vs* 4 is not the best way to develop the basis of endurance, but depending on a training period it can be used for the development of football-specific endurance.

Key words: football, running, adaptation

INTRODUCTION

Football as sports requires a complex of physical abilities, in which besides aerobic endurance essential qualities are velocity, jumping ability, muscle strength and anaerobic capacity. It is equally important for the player to be able to assess the course of the game and to have the court perception, the perception of the location of teammates and opponents, as well as the ability to "read the game" [5, 11, 12, 13, 16].

Football is a game of velocity and endurance where movements are mostly either jogging or walking-running. Parallel to this "basic movement" are conducted several cyclic and acyclic activities, whereas the level of velocity and general technical activities in the second half time should not decrease due to fatigue. It is important to maintain the efficiency of performance up to the last 15 minutes of the game when the possibility of goals is the greatest [1, 14, 16]. Earlier research has shown that during the first half time is covered by 5–9% longer distance than in the second half time and players of good aerobic working capacity are able to avoid this decrease [16, 18, 20]. Since contemporary football has become increasingly more intensive, the ability of quick recovery between spurts is essential in order to be ready for further decisive efforts [4, 16, 19].

It has been established that the mean HR of a football player during the game is in the range of 155–170 beats·min^{-1} (164–173 in the first half time and 154–169 beats·min^{-1} in the second half time), whereas the indices of halfbacks and forwards are to some extent higher than of fullbacks [4, 15, 20]. Certainly it has to be considered that HR during the game depends on several factors and is individual. Apor [2] has established in Hungarian high-level football players significant correlation between their mean O_2 uptake and final ranking in the first division. However, Dunbar and Docherty [8] showed a BLA profile to be more sensitive to changes in aerobic fitness than VO_2max when assessing game players. Such a submaximal testing also gives more information for training prescription in terms of setting individual training intensities.

The measuring of BLA concentration enables us to assess metabolic shifts occurring in the organism of a football player. The BLA level changes during the game and can increase to 8 $mmol \cdot l^{-1}$ or higher [13, 20, 21]. This proves that anaerobic processes have an important share in the working capacity of a football player. BLA concentrations at the end of the game depend on the player's activity in the last minutes. Movements that are made sideways, with one's back forward and with the ball take up more energy and the BLA content is higher than in case of ordinary running of the same velocity [12, 16]. The BLA concentration on the level of 4 $mmol \cdot l^{-1}$ enables us to assess the anaerobic threshold of a football player, i.e. the quality of his aerobic capacity.

As training means for developing aerobic endurance of a football player can be applied endurance exercises with or without the ball. In the first case coordinational activities and influencing the aerobic and anaerobic capacity through functional training are joined together. Balsom [3] has recommended to use for this purpose small game of 4 vs 4 on the court of 20x30m with 8 different ratios of work and rest. The results of his study showed that small game can be applied as a form of endurance training in football, as well as a means of ball command and technical skills. The author established that HR values during small game were equal to or even higher than in case of continous running without the ball. Small game increases the share of high-intensity activity during training, approximating it to the game situation and this is extremely useful from the viewpoint of the training specificity. However, it is not known whether this can be extended to the creating of aerobic basis. According to the hypothesis, high-intensity small game can, despite its positive aspects, have a negative effect on creating the aerobic basis of a young football player and continous running is possibly better suited for the purpose.

The aim of the study was to provide a comparative evaluation of the influence of complex loads (game+run+game) on the young football players' organism from the viewpoint of influencing aerobic capacity and to establish correlations between objective and subjective criteria in evaluating the effect of different training exercises and recovery periods.

METHODS

Subjects

The subjects were 8 young experienced male football players, mean age 18.5±2.0 yrs, height 177.5±5.1 cm, weight 71.3±5.9 kg. Testing was conducted in the autumn, at the end of competition period. All subjects did not exercise on the day before testing. The study was conducted at the usual training time at 5.00-6.30 p.m.. After experimental procedures and risks were fully explained, each of them gave written informed consent. The study was approved by the Medical Ethics Committee of the University of Tartu (Estonia).

Data Collection

The load consisted of 8-min intensive small game 4 vs 4 on a grass court of 20x30m. This was followed by 8-min running load while HR was kept in the bracket of 170–180 beats·min^{-1} and again a small game of 8 min. For maintaining the intensity of the game, 10 balls were used and whenever a ball occurred outside the court borders, the coach immediately threw in a new ball. Additionally, the players were continuously encouraged to maintain high intensity of the game. Tests were separated by 3-min intervals of passive recovery.

During the whole test and recovery HR was measured with Polar Vantage NV sporttester (Polar Electro OY, Kempele, Finland). Capillary blood samples were obtained by fingertip stick procedure immediately after each game and run and after the end of testing at the 5th and 10th min of recovery. BLA concentration was analysed enzymatically in duplicate with a Lange (Germany) analyzer in mmol·l^{-1} with ±0.01 mmol·l^{-1} accuracy.

For evaluating the perceived effort of a football player was applied the Borg CR 10 scale [6] in which 0 stands for the lack of effort and 10 for an extremely strong effort. Ratings of perceived readiness to begin a run or the next small game were obtained by our Perceived Readiness Rating scale [9, 10]. The scale has anchors of 1: not at all ready to begin and 5: completely ready to begin. The scale has 0.5-point steps, but athletes were allowed to evaluate their readiness, if desired, with the accuracy of 0.1 points (for example, 3.2 or 4.4). The Perceived Readiness Rating scale was always shown to the athlete when a rating was requested. Rating was requested during the first 10 sec from the beginning of each minute of a 3 minute recovery period between tests. A researcher informed the player before the experiment that such an assessment should include an integrated feeling of readiness, combining all sensations and perceptions, as respiration rate and depth, heart rate, fatigue in leg muscles, etc.

Statistical Analysis

All data were presented as mean ± SD. Pearson correlation coefficients were used to evaluate the relationships among the variables. Statistical significance was set at $p<0.05$.

RESULTS

Study results are presented in Tables 1, 2 and 3. Table 1 includes mean HR-s during the first 8-min game of young football players, BLA concentrations, perceived efforts and subjective readiness indices to begin a new activity.

Table 1. Objective and subjective indices immediately after first small game and during recovery ($\bar{X}$ ±SD).

	$\bar{X}$	±SD
Mean HR (beats·min^{-1})	179.5	13.2
Mean BLA concentration (mmol·l^{-1})	9.8	4.9
Perceived exertion rating	3.0	0.9
Perceived readiness ratings		
1st recovery minute	4.1	0.2
2nd recovery minute	4.6	0.4
3rd recovery minute	5.0	0.0

In Table 2 are presented the same objective (HR, BLA concentration) and subjective indices (evaluations of perceived effort and perceived readiness) for 8-min running load. It is noteworthy that the comparison of these data with the characteristics during the first small game revealed that in both cases the indices of HR, perceived effort and perceived readiness were very close. Considerable difference, however, emerged in mean indices of BLA concentration: following the first small game 9.8±4.9 mmol·l^{-1} and following the running load 5.6±2.4 mmol·l^{-1}.

Table 2. Objective and subjective indices immediately after running load and during recovery ($\bar{X}$ ±SD).

	$\bar{X}$	±SD
Mean HR (beats·min^{-1})	177.6	12.0
Mean BLA concentration (mmol·l^{-1})	5.6	2.4
Perceived exertion rating	2.9	0.3
Perceived readiness ratings		
1st recovery minute	4.3	0.7
2nd recovery minute	4.6	0.5
3rd recovery minute	5.0	0.0

Table 3 includes mean objective and subjective characteristics of the effect of the second 8-min small game and of recovery. Although mean HR during the second small game was by only 2 beats more than during the first small game, the BLA concentration was lower. The higher perceived effort rating and lower perceived readiness rating point to greater fatigue during the second small game.

Table 3. Objective and subjective indices immediately after second small game and during recovery ($\overline{X} \pm SD$).

	$\overline{X}$	±SD
Mean HR (beats·min^{-1})	181.1	10.7
Mean BLA concentration (mmol·l^{-1})		
after small game	7.6	5.0
5th recovery minute	4.9	2.1
10th recovery minute	3.6	1.3
Perceived exertion rating	3.9	1.3
Perceived readiness ratings		
1st recovery minute	3.5	1.1
2nd recovery minute	3.9	0.7
3rd recovery minute	4.4	0.6
4th recovery minute	4.6	0.5
5th recovery minute	4.8	0.3

Correlation analysis revealed a statistically significant ($r=-0.72$; $p<0.05$) relationships between BLA concentration after the first small game and perceived readiness of the first post-game recovery minute. Statistically significant relationships emerged also between post-running load BLA concentration and perceived readiness indices in the 1st and 2nd recovery minute ($r=-0.81$ and $r=-0.75$, respectively; $p<0.05$).

Blood lactate level in the 10th recovery minute following the whole set of exercises correlated statistically significantly with perceived readiness ratings in the 2nd ($r=-0.79$) and 3rd minute of recovery ($r=-0.72$) after conducting the whole set of exercises.

DISCUSSION

In the analysis of study results we proceeded from the requirements of football as a game and the needs of developing endurance as an essential physical ability for a football player.

Mean HR during the first 8-min small game of 179.5±13.2 beats·min^{-1} showed that load was conducted in the theoretical zone between anaerobic threshold and VO_2max. In essence, this is an intensive training means of developing endurance [7, 17]. This is confirmed by the relatively high level of BLA concentration at the end of small game (9.8±4.9 mmol·l^{-1}). In different studies [4, 15, 16] different values of HR and BLA concentrations have been established, however, mean HR in professional football players playing on normal-sized court has been about 170 beats·min^{-1} and mean BLA concentration 4–6 mmol·l^{-1}. As in our study participated young football players in whom the HR economy and lactate-removing ability are not sufficiently good, the yielded results were higher. The subjects' mean subjective evaluation of perceived effort was moderate (according to Borg), although by objective characteristics (HR, BLA concentration) the players should have evaluated the load as heavy. The difference between objective and subjective indices could have been caused by insufficient experience of the subjects in assessing the load. Since the effort was evaluated as moderate (5 points), complete readiness to begin a new activity was attained already by the 3rd recovery minute. Proceeding from the above, the effect of the applied small game on the organism of a young football player can be estimated as being stronger than in case of highly qualified players playing on normal-sized court. As a training means for developing aerobic endurance, the effect of the first small game was too intensive, especially when the aim was to develop aerobic endurance basis. In creating the aerobic basis, the applied loads should not exceed the anaerobic threshold [7, 17].

Since from the viewpoint of developing endurance we were also interested in the reaction of a football player's organism to running load, then following the first small game they ran for 8 minutes approximately on the level of HR 170–180 beats·min^{-1}. Post-running mean HR was 177.6±12.0 beats·min^{-1}. being slightly lower than during the first small game. However, BLA concentration values, compared with the ones during the first small game were considerably lower (5.6±2.4 mmol·l^{-1} and 9.8±4.9 mmol·l^{-1}, respectively, $p<0.05$). From here proceeds an important conclusion of the study: at practically the same heart rate the metabolic reaction of muscles of a young football player (on the basis of BLA concentration) to small game and running load differs greatly. When proceeding solely from HR, we can considerably underestimate metabolic shifts in the organism and make mistakes in assessing the influence of exercise. Evidently running load in even and moderate intensity promoted smaller increase in lactate concentration and better removal of lactate during work. For developing aerobic endurance basis in young football players moderate-intensity running load is considerably more preferable, since at nearly the same subjective effort ratings and practically identical HR-s the BLA concentration only slightly exceeds the classical anaerobic threshold level of 4 $mmol \cdot l^{-1}$ (5.6±2.4 $mmol \cdot l^{-1}$). Although for developing aerobic basis this running intensity is too high [7, 17], it is still more suitable for this purpose than small game. The optimality of this running load was also reflected in the attainment of complete perceived readiness by the 3rd recovery minute in the present study.

Mean perceived effort rating of the second small game was 3.9 points, approaching strong effort on the Borg CR 10 scale and pointing to increased fatigue. This is confirmed by slightly higher mean HR, compared with the first small game. However, as BLA concentration was lower in comparison with the first small game (7.6±5.0 and 9.8±4.9 $mmol \cdot l^{-1}$, respectively, it was evidently caused by unability to maintain high intensity of the game due to fatigue. Increased fatigue following the second small game is confirmed by the relatively slow recovery of BLA concentration: 4.9±2.1 $mmol \cdot l^{-1}$ by the 5th recovery minute and 3.6±1.3 $mmol \cdot ^{1}$ by the 10th recovery minute.

Following the second small game the effect of the whole set of exercises can be evaluated, and from the viewpoint of football as a game it can be estimated as stronger than in case of an average game on normal-sized court [4, 13, 16] where the majority of activities are conducted in aerobic regimen. From the viewpoint of developing endurance the described set (game+run+game) is too intensive for young football players because HR-s and BLA concentrations were relatively high. For creating aerobic endurance basis in young football players, it is advisable to include continuous running loads, whereas in case of small game it is difficult to regulate the optimal intensity.

Relationships between objective and subjective indices were evaluated with correlation analysis, revealing that subjective readiness to begin a new activity is statistically significantly more influenced by BLA concentration and the dynamics of its recovery. No statistically significant correlations were obtained between HR-s during different exercises and perceived readiness. The results are in good accordance with the results of earlier studies conducted by us on runners [9, 10]. Consequently, it is expedient to apply the measuring of BLA concentration for evaluating the influence of the exercises used in the training of football players as well. Additional information can be obtained from perceived effort and perceived readiness ratings.

In summary, by using objective and subjective indices in evaluating the influence of both small game and running loads, we can control the distribution of training loads of young football players and better manage the training process.

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NEUROMUSCULAR PERFORMANCE CHARACTERISTICS IN 10–12-YEAR-OLD CHILDREN WITH HEARING DISABILITY AND HEALTHY CONTROLS

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ABSTRACT

This study compared maximal handgrip force, isometric maximal force of the leg extensor muscles during uni- and bilateral contractions, and vertical jumping height during counter-movement jump in 10- to 12-year-old children with hearing disability (HD, n=13) and in age- and gender-matched healthy controls (n=25). No significant differences ($p>0.05$) in maximal handgrip force was observed between the measured groups of children. The girls with HD had less ($p<0.05$) absolute and body mass-related values of isometric maximal force of the leg extensor muscles during bilateral contraction as compared to other groups. The girls with HD had also less ($p<0.05$) isometric maximal force during unilateral contractions of the right and left leg than boys with HD and girls without disabilities. However, no significant differences ($p>0.05$) in isometric maximal force of the leg extensor muscles during unilateral contractions between the girls with HD and healthy boys was observed. A marked bilateral force deficit of the knee extensor muscles have been observed in children with HD and controls. The healthy boys had higher ($p<0.05$) vertical jumping height than boys and girls with HD, and healthy girls had higher ($p<0.05$) vertical jumping height than girls with HD.

Key words: children, hearing disorders, muscle force, jumping performance

INTRODUCTION

Hearing disability (HD) occur among about one percentage of population, whereas among pupils a significant hearing recession occurs to 0.1–0.3% of them, i.e. about 2 pupils out of a thousand [21]. It is known that in 2- to 11-year-old children with HD a development of motor functions are more delayed than in age-matched children without disabilities [8, 17, 22]. It is well known that in children with HD the motor development is due to the communication problems and often by other impairments more complicated than in healthy children.

The motor development of a child is an elaborated collection of morpho-functional alterations, during which the size, proportion and functions of the body change [1, 12]. The motor development of a child can be measured by such indicators of neuromuscular performance as voluntary maximal muscle force and the ability to generate muscle force rapidly (explosive force) [15, 16, 20]. Before puberty the development of neuromuscular performance depends on the co-operation of growth-related biological and morphological factors. The increase of muscle force indicators occur quantitatively — with the increase of cross-section area of the skeletal muscles, and qualitatively – with biomechanical alterations and improvement of neural control in connection with age and experiences [1]. Less information is available from the differences in neuromuscular performance in children with HD and without disabilities.

The aim of this study was to compare neuromuscular performance and anthropometric characteristics in 10- to 12-year-old children with HD and healthy controls. More specifically, we measured voluntary maximal handgrip force, isometric maximal force of the leg extensor muscles during unilateral (UL) and bilateral (BL) contractions, and vertical jumping height during counter-movement jump (CMJ). Correlation coefficients between neuromuscular performance and anthropometric characteristics were also calculated.

MATERIAL AND METHODS

Subjects

Thirteen children with HD aged 10–12 years (6 boys and 7 girls) and 25 age-matched children without disabilities as controls (10 boys and 15 girls) participated in this study. Children with HD were pupils at Tartu Hiie School and the control children were pupils at comprehensive schools in Tartu. None of the children had an impairment of visual, somatosensory or vestibular function. Informed parental consent was obtained prior to the children's participation in the experiment. The study carried the approval of the University Ethics Committee. The anthropometric characteristics of the subjects are presented in Table 1.

Table 1. The physical characteristics of the subjects. Mean±SEM.

Variables	Groups			
	Girls with HD (n=7)	Boys with HD (n=6)	Healthy girls (n=15)	Healthy boys (n=10)
Age (years)	11.0±0.4	11.0±0.2	11.4±0.4	11.6±0.3
Height (cm)	145.2±1.2	141.8±1.5	146.4±1.2	143.1±1.2
Body mass (kg)	37.6±3.7	35.8±3.3	36.7±1.7	35.5± 1.2
Body mass index ($kg \cdot m^{-2}$)	17.6±1.2	17.6±0.6	16.1±1.3	17.4±0.5

Twenty-four to 48 hours before data collection the subjects were given instructions and the muscle strength and vertical jumping performance testing procedures were demonstrated. This was followed by a practice session to familiarize the subjects with the procedures. Prior to testing, a 10-min warm-up period was used.

Apparatus and Experimental Procedure

Handgrip force measurement. A hand dynamometer (Lafayette, USA) and standard method were used to measure maximal handgrip force during UL contraction. The subject performed three trials for right and left hand and the greatest value was taken as maximal handgrip force. A rest period of 2 min was allowed between the trials.

Leg extensor muscle isometric force measurement. During the measurement of isometric maximal force of the leg extensor muscles during UL and BL contractions the subjects were seated on a specially designed dynamometric chair in a horizontal frame with knee and hip angles equal to 110° and 120°, respectively [16]. The body position of the subjects was secured by two Velcro belts placed over the chest and hip. The feet were placed on a footplate mounted on a steel bar held in ball-bearings on the frame. The isometric force production of the leg extensor muscles was recorded by standard strain-gauge transducer connected with footplate. The electrical signals from the strain-gauge transducer were digitized on-line (sampling frequency 1 kHz) using a personal computer. During testing the subjects were instructed to push the footplate as forcefully as possible for 2–3 s in three cases: 1) UL contraction of the right leg, 2) UL contraction of the left leg and 3) BL contraction in random order. Three trials were performed for each case and the greatest force value was taken as isometric maximal force. Verbal encouragement and visual feedback were used to motivate the subjects to produce maximal effort. A rest period of 2 min was allowed between the trials. During UL exertions the contralateral leg was allowed to rest. Bilateral index (BI) was calculated by the formula described by Howard and Enoka [7]: BI (%) = [100 – (BL /(UL_R + UL_L) ·100%], where BI is the bilateral index, BL is isometric maximal force during bilateral contraction, and UL_R and UL_L are isometric maximal force during unilateral contraction of right and left leg, respectively. A negative BI indicated a BL force deficit, while a positive BI indicated a BL force facilitation. Isometric maximal force of the leg extensor muscles during BL contraction relative to body mass was also calculated.

Vertical jumping test. The vertical jumping test was performed on force platform (PD-3A, VISTI, Russia) with the dimensions of 0.75×0.75 m and natural frequency of 150 Hz. Maximal counter-movement jump (CMJ) started from upright standing position immediately after a fast preparatory counter-movement that stretches the leg extensor muscles (eccentric contraction). This was followed by an explosive maximal extension in the opposite direction (concentric contraction). The subjects were instructed to jump with their hands on the hips to eliminate the influence of the arm swing impulse. Prior to the testing the subjects performed several preliminary trials. A vertical force-time curve recorded and jumping height as a of rise of the body's center of gravity was calculated by the formula: $H = g \cdot t_f^2/8$, where g is acceleration of gravity (9.8 m/s^2) and t_f is flight time. Three maximal CMJ were recorded and the trial with best jumping height was used for further analysis. A rest period of 1 min was allowed between the trials.

Statistical Analysis

Data are means and standard errors of mean (±SEM). One-way analysis of variance (ANOVA) followed by Tukey post hoc comparisons were used to test for differences between groups of children and for each hand or leg. Linear correlations were calculated to observe the relationships between the measured characteristics. A level of $p<0.05$ was selected to indicate statistical significance.

RESULTS

No significant differences ($p>0.05$) in height, body mass and body mass index (Table 1) and maximal handgrip force of the right and left hand (Fig. 1A) were observed between the measured groups of children. The girls with HD had less ($p<0.05$) isometric maximal force of the leg extensor muscles during BL contraction (Fig. 1B) and maximal force during BL contraction relative to body mass (Fig. 1C) as compared to other groups. No significant differences ($p>0.05$) in these characteristics were observed between the other measured groups. The girls with HD had also less ($p<0.05$) isometric maximal force of the right and left leg during UL contraction than boys with HD and girls without disabilities (Fig. 2A). However, no significant difference ($p>0.05$) in isometric maximal force of the leg extensor muscles during UL contractions between the girls with HD and healthy boys were observed. As shown on Fig. 2B, a marked negative BI, i.e. BL force deficit of the knee extensor muscles have been observed in children with HD and controls. The girls with HD had higher ($p<0.05$) BI than healthy boys. However, BI did not differ significantly ($p>0.05$) between the other measured groups. The healthy boys had higher ($p<0.05$) vertical jumping height in CMJ than boys and girls with HD, and healthy girls had higher ($p<0.05$) jumping height than girls with HD (Fig. 2C). No significant difference ($p>0.05$) in vertical jumping height was found between healthy boys and girls, and between boys and girls with HD.

In boys with HD the height and body mass correlated positively ($p<0.05$) with maximal handgrip force of left ($r=0.90$ and $r=0.82$, respectively) and right hand ($r=0.94$ and $r=0.86$, respectively), and with the jumping height in CMJ ($r=0.84$ and $r=0.84$, respectively). Maximal handgrip force of the right hand in boys with HD correlated positively ($p<0.05$) with jumping height in CMJ ($r=0.88$). In girls with HD the maximal handgrip force of right hand correlated positively ($p<0.05$) with height ($r=0.72$), and the maximal handgrip force of left hand correlated positively ($p<0.05$) with the jumping height in CMJ ($r=0.87$). In healthy boys positive correlations ($p<0.05$) appeared between height and isometric maximal force of the leg extensor muscles during BL contraction ($r=0.66$), and between maximal handgrip force of left hand and jumping height in CMJ ($r=0.70$). A negative correlation ($p<0.05$) between height and BL force deficit of the leg extensor muscles ($r=0.67$) has been observed in healthy boys. In healthy girls maximal handgrip force of left and right hand correlated positively ($p<0.05$) with height, body mass, and body mass index ($r=0.85$, $r=0.82$ and $r=0.69$, respectively), whereas the maximal handgrip force of left hand correlated positively ($p<0.05$) with the jumping height in CMJ ($r=0.53$).

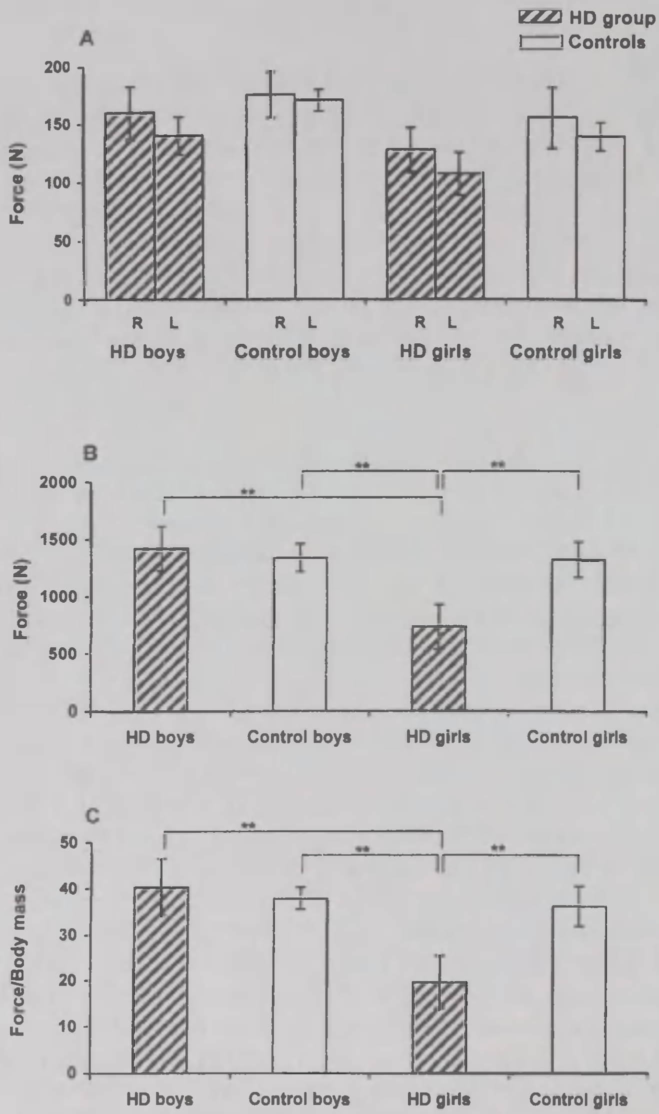

Figure 1. Mean (±SEM) maximal handgrip force (A), isometric maximal force of the leg extensor muscles during bilateral (BL) contraction (B) and maximal force during BL contraction relative to body mass (C) in children with hearing disability (HD) and healthy controls. R – right hand; L – left hand.
** p<0.01

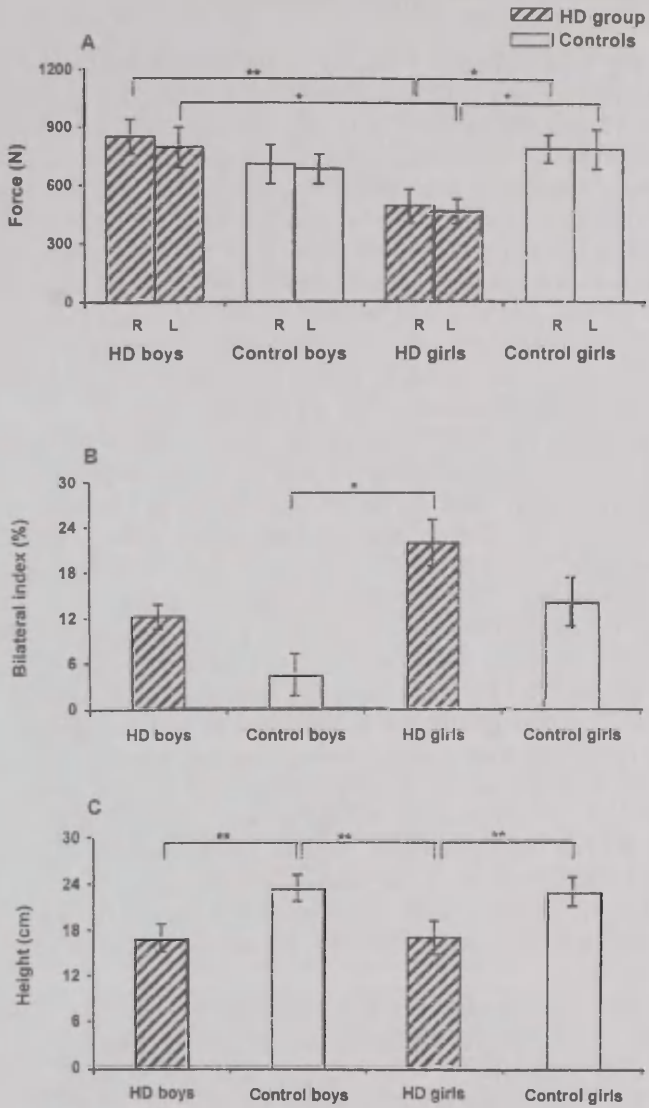

Figure 2. Mean (±SEM) isometric maximal force of the leg extensor muscles during unilateral contractions (A), bilateral index (B) and vertical jumping height (C) in children with hearing disability (HD) and healthy controls. R – right leg; L – left leg.
* p<0.05; ** p<0.01

DISCUSSION

In this study were registered a number of anthropometrical and voluntary maximal isometric and explosive muscle force production characteristics in 10- to 12-year-old children with HD and age- and gender-matched healthy controls. No significant differences in anthropometrical indicators (height, body mass, body mass index) was observed in girls and boys with HD as compared to healthy children. Maximal handgrip force did also not differ in the measured groups of children. Thus, the present data indicated no significant differences in general physical development characteristics in 10- to 12-year-olds with and without disabilities, neither were established any gender differences in these characteristics. However, a marked difference between the measured groups appeared in voluntary maximal and explosive force production of the leg extensor muscles.

The girls with HD had a significantly lower isometric maximal force of the leg extensor muscles during UL and BL contractions, and maximal force relative to body mass during BL contraction as compared to other measured groups. It is known, that voluntary muscle force production depends on central factors (recruitment of motor units) as well as peripheral factors (muscle mass, diameter and contractile properties of muscle fibres) [2, 9]. In comparison to other measured groups the girls with HD did not differ in body mass, which is related to muscle mass. For this reason, it can be assumed that the lower isometric force-generating capacity in the girls with HD occurs mostly due to their smaller ability to recruit motor units and coordinate their muscles during maximal voluntary action. It is known that in childhood the development of muscle force production is dependent on growth-related biological and morphological factors' cooperation. The force-generation capacity of the muscles is dependent on the myelination of the motor nerves and the maturity of the nerve system [3, 5, 6]. Because of the myelination of a number of motor nerves is not completed until sexual maturity, the neural control of muscles is also limited [6].

Some authors have observed that before puberty occur no significant differences in muscle force characteristics between healthy boys and girls [3]. However, according to other authors [16], the isometric maximal force of the leg extensor muscles during UL and BL effort in girls is considerably smaller compared to boys at early pre-school age. No significant differences in isometric maximal voluntary force of the leg extensor muscles between 10- to 12-year-old healthy boys and girls have been found in the present study.

This study indicated a marked BL force deficit of the leg extensor muscles in children with HD and without disabilities. BL force deficit was significantly higher in girls with HD than healthy boys. Several investigators have reported a reduction in isometric maximal voluntary force induced by simultaneous BL voluntary contraction as compared with the sum of maximal force of separately performed UL contractions of the right and left legs in adult subjects [4, 13, 14, 18, 19, 23]. Neural mechanisms seem to be the likely cause of the BL force deficit. A force deficit during BL contraction would occur if central drive is decreased or antagonist co-activation increased. The nature of the neural mechanism must ultimately involve altered motor unit discharge frequency and/or recruitment during maximum BL contraction. The BL force deficit can be caused by a reduced activation of either low threshold (slow) motor units [19] or high threshold (fast) motor units [23]. Some investigators have suggested that BL force deficit is the consequence of a disproportionate increase in antagonist co-activation [7]. One explanation for the BL force deficit is that it could be neural interaction between the two hemispheres connected by comissural nerve fibres [13, 14]. It has been shown that BL force deficit was associated with reduced movement-related cortical potentials caused by a mechanism of interhemispheric inhibition [4, 13, 14]. However, Jakobi and Cafarelli [10] demonstrated no evidence of a significant limitation in motor control between BL and UL isometric contractions of the knee extensor muscles in young male subjects. Thus, the mechanisms of BL force deficit themselves have been discussed but are still unclear.

Vertical jumps can be used as a model to study explosive force-generating capacity of the leg extensor muscles. In the present study, significant differences in vertical jumping height in CMJ in healthy children and children with HD was observed. However, there were no significant differences in vertical jumping height in CMJ in healthy boys and girls, and in boys and girls with HD. Vertical jumping is a multijoint movement and requires the intra- and intermuscular coordination, which describes the ability of muscles engaged in a movement, i.e. the ability of agonists, antagonists and synergists to co-operate in performing the task [2]. The lower vertical jumping performance in children with HD than in children without disabilities can be connected with a poorer ability to control and adjust precisely movements according to needs [11]. It has been shown that in children with HD a development of gross motor function was more delayed as compared to age- and gender-matched children without disabilities [17, 22].

The present study showed that in the boys with HD and in healthy girls height and body mass correlated positively with the maximal handgrip force of the right and left hand. Moreover, maximal handgrip force of left and right hand in healthy girls correlated positively with the body mass index. Several earlier studies have shown a markedly positive connection between muscle force and body mass index in prepubertal children [3, 20].

It was concluded that no significant differences in body size indicators and maximal handgrip force were observed in 10- to 12-year-old girls and boys with HD as compared to healthy children. Isometric maximal voluntary isometric force-generating capacity of the leg extensor muscles during bilateral and unilateral contractions was considerable lower in girls with HD as compared with age-matched boys with HD and healthy boys and girls. Vertical jumping performance is significantly lower in children with HD than healthy controls. The lower neuromuscular performance characteristics in children with HD compared with healthy children seemed to be related to differences in the development of motor control mechanisms.

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MANUAL MASSAGE DOES NOT INFLUENCE REPEATED SWIMMING PERFORMANCE

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ABSTRACT

The use of massage in aiding recovery and enhancing performance is commonplace in competitive athletics. Despite this there is very little evidence as to the efficacy of massage in enhancing subsequent competitive performance following intense effort. To address this question, the influence of massage on repeated swimming performance was determined using 10 competitive swimmers. A counterbalanced repeated measures design was used with either 10 min of massage therapy, placebo ultrasound (with no ultrasound generation) within 20 min of rest, or rest alone, inter-spaced between four maximum effort 200m freestyle swims. Subjects completed each swim series trial in random order with one week between trials. Times for each swim and stoke counts for the third 50 m of each swim were recorded. To minimize inter-subject variability swim performance was calculated as the sum of the differences between individual swim times and personal best times. No significant ($p>0.05$) differences in swimming performance or stroke counts were seen between massage therapy, placebo ultrasound or rest conditions. These findings do not support the use of massage therapy for enhancing recovery or improving performance in repeated intense swimming conditions.

Key words: massage, swimming, fatigue

Manual massage is commonly used in athletic settings in an attempt to enhance recovery following intense exercise [3, 10]. In Canada and other parts of the world, swimming teams often employ a massage therapist to aid athlete recovery between events (personal observations). Despite its relative popularity in athletic settings as a putative aid to performance recovery [4], relatively little empirical or physiological evidence exists as to the efficacy of athletic massage in enhancing post-exercise recovery or repeated intense athletic performance [7].

Muscular fatigue is a multi-factoral process with potentially numerous sites of fatigue in the excitation contraction process, dependant on the intensity and/or duration of muscular contractions [5]. The potential effects of massage on most of the potential physiological factors associated with neuro-muscular fatigue and recovery have never been investigated [10]. Those indirect factors that have been investigated, such as the effects of massage on post-exercise blood lactate clearance [6, 7] and muscle blood flow [2, 9, 12] have generally not demonstrated any positive influence of massage.

The few well controlled studies that have examined the potential of massage to enhance recovery or repeated performance in single muscle groups have generally reported little positive influence [1, 2]. Even less empirical data exists on the potential for massage to aid recovery or enhance repeated sports performance in actual athletic settings. In one of the few studies on this topic, massage administered during recovery between bouts, failed to improve repeated boxing performance over rest alone in experienced boxers [7]. Few other peer reviewed publications exist on the potential for massage to enhance repeated performance by athletes in simulated competition settings. Despite these potentially negative results, the belief in massage as a ergogenic aid to recovery among athletes and coaches is still positive.

Since the effects of athletic massage are under-researched, this study was undertaken to ascertain the potential for massage performed during recovery between intense swimming bouts to influence repeated swimming performance in a simulated racing setting.

METHODS

Ten experienced competitive swimmers (4 male and 6 female) participated in the study. All subjects were university level varsity swimmers with 6 or more years of competitive swimming experience and a mean age of 20.6 y (range 20–22 y). All subjects were training regularly (minimum of 7 practices per week at the time of the study). The study was approved by the Wilfrid Laurier University Human Research Ethics Committee.

The study attempted to simulate the swimming intensity and typical rest interval available between races characteristic of varsity dual meet swimming competitions in mid-season. Hence, as typically seen in these competitions, subjects competed untapered and were instructed to go through their typical pre- meet preparations as if they were to compete in a dual meet. All subjects participated in three identical testing situations, separated by one week. On each testing date all subjects performed 4 maximum effort 200 m freestyle swims (starting from an in-water push off from the wall) in a 25 m pool with a 20 min break between swims. To simulate race conditions 4–6 swimmers (one per lane) swam simultaneously. During the three breaks (following swims 1–3 and preceding swims 2–4), participants experienced one of three conditions; manual massage, placebo ultrasound or untreated rest. Hence each treatment condition was repeated 3 times (prior to swims 2–4). Prior to beginning the swims, all subjects participated in a typical pre-meet warm up for approximately 30 min. The warm up consisted of light exercise, swimming and stretching. No massage, placebo ultrasound or rest treatment preceded the first swim.

The massage treatments were performed by two professional registered massage therapists, experienced with treating swimmers. Massage treatments were designed by the therapists to (in their professional opinion) aid post-exercise recovery and included effleurage and petrissage massage of deltoid, quatriceps, latissimus dorsi, triceps and pectoralis muscles (the muscles most used during swimming). The treatments were standardized such that both massage therapists employed identical protocols. The ultrasound treatment was employed as a placebo for the massage. The ultrasound machine was turned off and the subjects lead to believe that the machine was in fact on. The placebo ultrasound treatment used a 5 cm transducer head moving small circles on the skin with contact via ultrasound treatment gel. The placebo ultrasound was performed on the deltoids, latissimus dorsi and triceps muscles. The rest condition acted as a control, during which subjects were seated and rested quietly.

Each treatment (massage and placebo ultrasound) was 10 min long. The remaining 10 min between each swim was allotted for exiting/entering the pool, drying off etc (as would normally occur during meet conditions). The experiment was conducted as a repeated measure design with all subjects experiencing each of the conditions in random order with one week separating each trial.

Time for completion of each 200 m swim for each swimmer was determined by an experienced timer using a manual stop watch. Since the object of the study was to determine the effects of massage on recovery and repeated swimming performance, the times for swims 2, 3 and 4 (which were preceded by the treatments conditions) were used for analysis. To minimize inter-subject variability, the personal best 200 m freestyle time for each swimmer was subtracted from times for each of swims 2–4. The resultant times were added together for each swimmer to determine the effects of each treatment condition on subsequent swimming performance and fatigue.

Stroke counts (number of strokes taken to complete 50 m) for each third 50 m of the 200m swims was also recorded. The stroke counts for swims 2–4 (which were preceded by the treatment conditions) were recorded and averaged for each swimmer. The average stroke counts for the third 50 m for swims 2–4 were used for analysis. Stroke counts act as another measure of fatigue since as a swimmer loses force with fatigue each stroke becomes less efficient. Therefore if fatigue increases, so should stroke count.

A one-way repeated measures design ANOVA was employed to determine the effect of the various conditions/treatments on swimming time and stroke count. Significance was set a priori at $p<0.05$.

RESULTS

The results of the times for swims 2–4 (as a sum of differences between each time swum and each swimmers personal best times) are depicted in Figure 1. There were no significant differences between massage, rest or placebo ultrasound conditions ($P = 0.456$). Swimmers' 200 m swim times averaged 12.7 sec slower than their personal best times over swims 2–4 and 1.5 sec slower than swim 1 (prior to the first rest/treatment cycle). Although swimmers tended to slow down as swims progressed from 2–4, there was no real systematic change in swim times as the swimmers times were usually within a few seconds (faster or slower) than the previous time.

The results of the mean stroke counts for the third 50 m of each of swims 2–4 are depicted in Figure 2. There were no significant differences between massage, rest or placebo ultrasound conditions ($P =0.936$). There was no systematic change in stroke counts as swimmers progressed from swims 2–4.

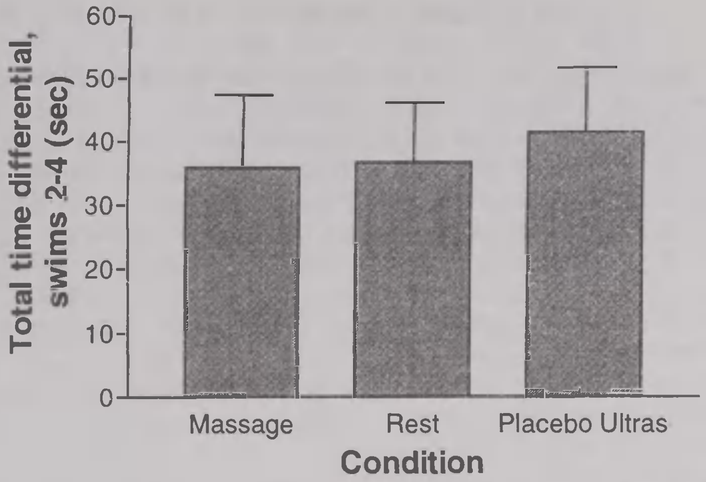

Figure 1. Cumulative time differential (from personal best times) for swims 2–4 (preceded by massage, rest or placebo ultrasound conditions). Means and standard deviations. No significant difference (P=0.456) between any of the conditions.

Figure 2. Mean stroke counts for the third 50 meters of swims 2–4 (preceded by massage, rest or placebo ultrasound conditions). Means and standard deviations. No significant difference (P =0.936) between any of the conditions.

DISCUSSION

This is the first study to attempt to determine the influence of massage treatment applied between intense swimming bouts on subsequent swimming performances. This was an attempt to approximate competition conditions rather than looking at the potential for massage to influence fatigue in a single muscle group. With a few exceptions [7], the effects of massage on fatigue and repeated athletic performance have rarely been determined on athletes in simulated competition conditions [4]. By comparing the effects of massage intervention between 200 m swims to both a control rest and, placebo treatment (ultrasound) conditions it was hoped that both massage treatment and placebo effects could be accounted for. Despite this, no effects of 10 min massage treatments applied between four repeated 200 m swims on post-massage swimming performances (as determined by swimming times and stroke counts) were seen in this study. This agrees with findings of most of the limited number of previous studies regarding the ineffectiveness of massage in aiding recovery and forestalling fatigue in whole body athletic performance or isolated muscle contractions [3, 7, 11].

Performance of and recovery from short intense bouts of swimming may be limited by numerous cellular, sub-cellular, organ and whole body related physiological mechanisms [5]. The potential for massage to influence most of these potential physiological mechanisms has never been experimentally assessed [10]. Some fatigue related measures such as rate of post-exercise blood lactate clearance [6, 7]. muscle blood flow [9, 12] and short term recovery of muscle force [1] have not been significantly influenced by massage. Although relaxation and psychological benefits from massage have been reported [7, 13], there is little evidence for this influencing actual sport performance and recovery [7, 10].

Hence its relatively widespread popularity among athletes notwithstanding, the results of this study in combination with the other evidence cited does not support the use of massage as an aid to short term, post-exercise, recovery or performance enhancement. There is little physiological or performance based evidence available to support claims of the efficacy of massage as a short-term restorative treatment in athletic settings. Despite this tentative conclusion there are limitations to this study that may limit the application of its findings for actual competition settings. Although the participants were motivated to give maximum effort, they did average over 12 sec slower than their personal best times for 200 m freestyle over all four swims. Part of this was due to the fact that the experiment was conduced in mid-swim season during a heavy training period when the athletes were not rested or tapered as they would have been when swimming their best times. Further, the in-water wall start (used to aid consistency of the swims) is slower than a dive start. Additionally, since the experiment only simulated racing conditions, and required four repetitions, it may have been more difficult for the swimmers to provide the repeated maximal efforts they might have in an actual competition setting. Therefore, the degree of fatigue they experienced (and hence the potential influence of massage) may not necessarily correspond to that which may have occurred during an actual intense competition.

It is also possible that swimmers recovered sufficiently following 20 min of rest between swims 2–4 that any potential influence of massage was minimized. However, it is precisely with this type of rest interval or longer that massage is employed in swimming competitions, where its positive efficacy is alleged to occur. It is well known that following intense exercise, blood lactate levels would be returning toward normal levels after 20 min of rest or active recovery [8]. However, since it has been repeatedly demonstrated that blood lactate clearance is not influenced by post-exercise massage [6, 7], this mechanism would not explain any putative influence massage may have on post-exercise recovery or performance.

Despite these caveats, this study did not find any evidence for the ability of massage treatments administered between short intense swimming bouts to influence subsequent swimming performances in experienced competitive swimmers, within the limitations of this study design. Hence the use of massage therapy for the purpose of enhancing post-exercise performance and recovery of athletes should be questioned.

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ANALYSIS OF SPORT INVOLVEMENT PATTERNS OF PARENTS AND THEIR SOCIODEMOGRAPHIC STRUCTURE IN SLOVENIA

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ABSTRACT

A sample of 2760 female and 2760 male (all together 5520) parents, whose children attend primary school in Slovenia, was examined by means of a questionnaire in order to reveal characteristics of parental socio-demographic structure in Slovenia and correlate it with their sports activities. We applied factor analysis using first main component. In the study, the women's (mothers') position in a whole demographic region and sports world was pronounced and highlighted. Different stereotypes are present in Slovenian society. Most of them still contain a constraint of women's participation in sports activities, instead of aims to assist them to recognise how important is sport for a modern women, for their quality of life and family cohesion. However, the results show that women, although deprived in their own sports activities, play a dominant role in forming of family sports life pattern.

Key words: socio-demographic structure, parents, sport activity

INTRODUCTION

Sport is a social phenomenon that carries with it both positive and negative characteristics of relations and processes in a given society. The inclusion of an individual into sport activities as a rule depends to a large extent on the relative position of an individual on the scale of social hierarchy. This is in turn connected with the determinants of the social status of an individual, and hence also with the sex.

Various sport activities are still to a large extent connected with the members of those social groups who occupy high positions on the various scales of the social status. Even the so-called mass sports are actually not sports of the masses. The inclusion of individuals into sport activities depends both on the social group to which they belong, their social status, and last but not least, also on their sex.

The study of sociodemographic characteristics in sports has been the subject of a larger number of investigations in Slovenia up to now; however, there have practically been no investigations dealing with the pattern of female population. In Slovenia there have almost been no discussions dealing with the subject of female sports, not to mention the execution of any scientific research projects. As a consequence, the position of women is only seldom dealt with. In the past, the study of women was labelled to be of no special importance and not interesting in the analyses of division of power, wealth and prestige. This additionally confirms the fact that sex in itself can be an important factor of social stratification.

The differences between the sexes were most often explained in Slovenia with respect to some biological, anatomic, physiological criteria, while the two main issues have almost never been the focus of attention, namely the socio-demographic position of women in society and their position in the family. Thus, the two central issues concerning sports have been put aside and disguised with less or more success.

All the above said is exactly the main reason for the present research by which we have tried to establish the socio-demographic structure of the parents with children of school age and the relation between the sociodemographic structure and sport activities of parents, focusing attention on the position of mothers.

MATERIAL AND METHODS

Into the sample of measured subjects, 5520 parents have been included: from this number 2760 persons were females and 2760 persons were males — parents of children of school-age living in the Republic of Slovenia. The sample was stratified according to the regions (10 places), and selected at random inside the regions.

The sample of variables has been drawn on the basis of a phenomenon model of social stratification [3] which consists of the following variables:

Social status
- Age,
- education,
- size of the family.

Economic status
- accommodation conditions,
- possession of a car,
- possession of goods of permanent value.

Sport activity
- sport activities,
- the manner of sport activity ,
- number of exercising hours on workdays,
- number of exercising hours at weekends.

Opinion about physical education
- physical education in the primary school during the schooling of the parents.

Attitudes toward sport
- 27 different attitudes.

As a measurement procedure survey was used. It followed such a principle of the nomination of the modalities of answers which are hierarchically distributed so that they allow processing with multivariate methods. Included into the survey was a reduced set of variables which originates from the modified phenomenon model of social stratification [3]; however, this set of variables has proven in similar investigations on other samples as a set of variables which provides sufficient information.

To establish the latent structure of the used manifest variables, we employed factor analysis. Due to the fact that in sociological investigations only oblique transformations are important, we transformed the typical main axes into Oblimin position. In this way, we obtained coordiantes of the vectors of manifest variables in the oblique coordinate system. Multidimensionality of the socio-demographic space is in our case narrowed to 5 latent dimensions which are defined with various manifest stratification indicators.

RESULTS AND DISCUSSION

Table 1. Factor analysis of variables of social stratification variables (after oblique rotation with Oblimin method and Kaiser normalisation).

Variables	1 Factor	2 Factor	3 Factor	4 Factor	5 Factor
Age — mother	–.03466	.82366	.00367	–.05408	–.04751
Age — father	–.04091	.90147	.01981	.00126	.02751
Education — mother	.19071	.06933	.04394	.03519	.63616
Education — father	.13857	.00721	–.01084	.05812	.62029
Size of the family	–.16169	–.10056	–.00316	.01576	–.01825
Accommodation conditions	–.04100	–.17246	.02407	–.01446	.30665
Possession of a car	–.08520	.01818	–.02742	–.02469	.67962
Possession of goods of permanent value	.00383	.02063	–.04580	–.00433	.64476
manner of sport activity — mother	.43268	.01201	–.23641	.07746	.14790
manner of sport activity — father	.55248	–.02234	–.09702	.08070	.02550
exercising hours on workdays — mother	.13911	–.00161	–.48560	.02206	–.04054
exercising hours on workdays — father	.22344	.00568	–.43258	.03484	–.05174
exercising hours at weekends — mother	–.14179	.01563	–.81984	–.06599	.07488
exercising hours at weekends — mother	–.08152	–.03218	–.72333	–.04321	.02281
Opinion about PE — mother	.00173	.01924	–.00579	–.74240	.05182
Opinion about PE — father	.05824	.00753	–.03914	–.51614	–.05798
Attitudes toward sports — mother	.67808	–.01738	.00092	–.18395	.09804
Attitudes toward sports — father	77891..	–.06211	05223	–.10829	01067

1. ***factor — Sport as a privilege of men***
- father's attitudes toward sports (0.78)
- mothers's attitudes toward sports (0.68)

- the manner of father's sport activity (0.56)
- the manner of mother's sport activity (0.43)
- size of the family (0.16)

Comparing sport activities of mothers and fathers, we find that the involvement of fathers in sports is much higher. This fact can serve us as an indicator that the social consciousness of the involvement of women in sports is far below the real needs and possibilities.

If we look at the involvement of women in sport activities of both sexes according to age categories, this fact is clearly evident. At the beginning of the primary school, involvement of girls in sports is still almost equivalent to that of boys, whereas at the beginning of the secondary school, the lagging back of girls behind boys in sport activities is already considerable. At faculties, this negative trend increases as a rule, not to speak of the activities of girls outside faculties as the investigations show that for the majority of women sport activities end at the age of twenty [2].

It is obvious that in our society, involvement of women in sport activities is still of a secondary social import. It is certainly invaluable that women are also actively involved in sports, however, their activity cannot be compared with sport activities of men. This means that we cannot assess them on an equal basis and it does not surprise that sport is basically considered to be the domain of men which should be defended against the members of the opposite sex. In this way, the image of female inferiority in sports is maintained as a welcome means for keeping up the hierarchy between sexes and the stereotypes about female features, behaviour and abilities in general.

In Slovenia it is almost 15 years since the introduction of aerobics, but strong opposition to this primary female sport activity is still felt both on the level of individual conjugal partners and on the level of a wider environment. This applies especially to those families in which fathers must take care of children during the absence of the mother. However, the number of women that are actively participating in sports increases despite that, above all among women that are economically better off, especially in that period of life when they have already solved their basic economic problems and have also, to some extent, organised the life of their children. The number of women who actively take part in sports increases especially when they become aware of the fact that they should do something for themselves and their lives.

2. factor — age
- age of father (0.90)
- age of mother (0.82)

It is also necessary to point out that the average age of parents having children of school-age is 37 years, thus we can say that we have to do with a group of parents who have already attained that point in acquiring economic advantages when they have no financial problems anymore, and can as a consequence devote themselves more to other values of life. Concerned is that proportion of the population whose opinions and views concerning sport, and thus also values of life, have already been formed.

The way of thinking of an individual expresses especially importantly in values. However, the fact is that values, especially those having general cultural significance, are very stable. Their change can be expected only in very large social shifts; such shifts have doubtless occurred in the former socialistic countries. The change of the values of the parents of children of school age is logical due to the fact that at their age there began to form political ideas which consider sport as a life style. General opinion of sport activity in Slovenia is more and more moving from the concept of physical exercising over harmony between body and spirit towards the concept of life style.

3. *factor — Sport activity as a way for spending free time*
- number of mother's exercising hours at weekends (–0.82)
- number of father's exercising hours at weekends (–0.72)
- number of mother's exercising hours on workdays (–0.49)
- number of father's exercising hours on workdays (–0.43)

Despite the changed values, patriarchal family is still very strongly present in our society. Men (fathers) are most active in sports during the week, women (mothers) on days when they do not go to work. It is obvious that the structure of division of work in (patriarchal) families is such that mothers as a rule do not have free time on workdays.

Mothers are slightly more active at weekends or during holidays. However, this greater sport activity is probably the result of lack of sport activity of mothers on workdays, so that the larger number of exercising hours on Saturdays and Sundays has a compensating role. However, from the aspect of sports theory, daily sports exercising and not only at weekends is ideal. This ideal has its psychological, educational and also social dimensions. In other words, this ideal requires awareness, time, financial basis and, of course, support and stimulation of society.

Mothers are mainly actively engaging in sports together with their children. This means that they use their free time to socialise with their children, participating at the same time also actively in sports.

With respect to the fact that the most frequent sport activities of Slovenian women are walking and excursions [4], we may conclude that at weekends women go for walks together with their children. In short, they are active in sports within the scope of their families.

Too often the attitude of women towards sports shows only as servility and serving to others, both as regards the role of their sexuality, by which they make male sport more attractive (majorettes), or their work (cooking, washing, etc), by which they make possible for other members of the family to participate in sports. The recognition of patriarchal control of men over women, the maintenance of the idea that children are only the responsibility of women, the never questioned notion about the value and status of female sports and spending of free time are essential political issues as regards women and sports as is the role of education which ensures that the situation remains unchanged.

4. *factor — Opinion about physical education*

- mother's opinion about physical education in the primary school during her schooling (–0.74)
- father's opinion about physical education in the primary school during his schooling (–0.52)

Physical education in primary schools is good in Slovenia, maybe its quality is even better than in many more developed countries, but despite that in the thinking of many people there is still present the negative sign when physical activity of girls is concerned. That sport is not suitable for women do not think only older people, but also children — even girls themselves [1]. Many have also patterns of sport activities formed on the basis of stereotypes what should be regarded as suitable for the female and respectively what for the male sex.

5. *factor – education as a pointer of material status of family*

- possession of a car (0.67)
- possession of goods of permanent value (0.64)
- mother's education (0.64)
- father's education (0.62)

- accommodation conditions (0.31)

Education is also that which determines some of the goods of a more permanent value. There exist professions which despite lower educational level ensure high income and in Slovenia we have a layer of people with low educational level and high income (craftsmen, entrepreneurs); however, the proportion of such people is relatively small and has no effect on the change of the basic interrelation between education and possession of goods of permanent value.

Education and economical status of mothers have, over the attitudes towards sport, the largest effect on their actual sports activity. This means that the access to cultural values, goods and services of leisure time (in our case sport) is limited due to the fact that sports activity of an individual is determined by the extent of his capital. However, this is not only an economical, but also a cultural (e.g., education) aspect.

CONCLUSIONS

With the analysis of conditions (or reasons) for actually active participation of men and women in sports we have found that sex differences in sports show also in the society of today as the basic foundation stone of patriarchality. Recognition of sex differences allows a whole series of physical, social, emotional and sex properties, based on that what behaviour is suitable for the particular sex, what is the “ego” of masculinity and what the “ego” of femininity. Preservation of male power and privileges depends partly on the conviction that sex differences are accurately structured and institutionalised in social structures and in practice. Sport with the preservation of definitions concerned with the physical ability and physical behaviour ensures also today a suitable scene for teaching the lessons about masculinity and femininity.

The development of masculinity as the process of learning power in a patriarchal social structure is gradual and lasts a whole life. In youth, the image of a man’s body represents power in society. Sport and masculinity are often synonyms for competition, courage and power. Hence, to be a man means to be the carrier of masculinity, to have identity, social role. Many enter the world of sport with an already formed identity on sex which affects their evaluation of the game and sport. The socially built male identity develops and changes with the growing up (by the acceptance of the values of a given society). At a more mature age when physical work is not anymore the embodiment of power, men begin to express their masculinity in other ways. They start to devote themselves to the "substitutes" for the expression of masculinity such as work, training, keeping up-to-date with sports and sport events.

Sport is an activity over which men (boys) and women (girls) learn the differences between the sexes, the activity in which men take over the role of a "macho" for which competition is typical. Boys are encouraged through sport to look upon their body as an object with which they can reach the world of an adult man. Sport is a means of culture over which boys become the bearers of masculinity and patriarchy. Women have no other choice but to adjust to the prevailing rules and assume a subordinate position in society (sport).

Social nature of an individual is, as already mentioned, formed under the influence of general society and especially under the influence of the family. These two are especially important in the formation of personality of each individual and form the foundation which is inseparably related to the biological development and psychosocial properties.

In sport, women in Slovenia have made a large step towards equality with men, however, this process is far from being completed. Though inequality has been established, the reasons and possible solutions still remain uninvestigated. The reasons are sex stereotypes and various prejudices which are still present and deep-rooted.

Slovenia has ratified numerous charters in the field of sports. However, the declaration on female sport [5] has not been accepted yet in Slovenia, and the general issues of female sports have not been approached systematically for the time being. Even in the event of possible acceptance of the mentioned declaration — taking into account the fact that the acceptance of certain views and acknowledgement of the existing problems within the scope of a certain declaration (in our case the declaration on female sports) does not necessarily mean any changes in real life — a lot of effort will be necessary to change not only of the way of thinking, but primarily also the actual position of women in sports.

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INSTRUCTION TO AUTHORS

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2. Abstract (up to 200 words, separate sheets).

3. Text

The text should contain the following sections: Introduction, Materials and Methods, Results, Discussion, References, Acknowledgements if any. Tables and Figures should be presented on separate sheets. Figures should be professional in appearance and have clean, crisp lines. Identify each Figure by marking lightly on the back, indicating, Figure number, top side and abbreviated title of manuscript. Legends for the Figures should be submitted on a separate sheet. Tables should be double-spaced on separate sheets and include a brief title. The SI units should be used in presenting results.

Each citation in the text must be noted by number in parenthesis and must appear in the reference list as well. Each entry in the reference list must be double-spaced, arranged alphabetically and numbered serially by author with only one reference per number. Non-english papers should be cited in the original language.

Entries in the reference list should be as follows:

1. Sarna S., Kaprio J. (1994) Life expectancy of former elite athletes. Sports Med. 17 (3): 149–151
2. Gurpide E. (1975) Tracer methods in hormone research. Springer Verlag, New York
3. Morgan W. P., Borg G. (1976) Perception of effort in the prescription of physical activity. In: The humanistic and mental health aspects of sports, exercise, and recreation, T. Craig (ed). Chicago: Am. Med. Assoc. 256–259
4. Paoletti R. (1994) Future directions in drug treatment of atherosclerosis. 8th Int. Dresden Symp. on Lipoproteins and Atherosclerosis. Abstracts. Dresden, June 10–12, 1994, 22.

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