Physiological profiles of young boys training in ballet

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In order to evaluate physiological characteristics in young male ballet dancers, 27 boys (aged 9 to 16 years) who participated in a boys' dance course during the Kuopio Dance and Music Festival in June 1988 were studied. In general, the boys had started dancing at the age of 8.6 years and had been training for 4.1 years. They had, on average, three dancing sessions per week and the mean time spent on dancing was four hours per week. In the study, some anthropometric measurements were taken, the maximal oxygen uptake (VO_2 max) was measured by a cycle ergometer test and the explosive strength and the mechanical power of lower extremities were evaluated by a jumping test. The results indicate that boys who train in ballet are in general moderately lean, have relatively small body size and a high degree of flexibility. The younger boys especially have only moderate aerobic power, but both explosive strength and mechanical power in leg muscles are good in ballet trained boys.

Keywords: Boy dancers, anthropometry, aerobic power, muscle performance

Introduction

Theatrical dance is one of the most physically strenuous of the artistic professions. Ballet dancers start their regular training while young and specialize early. It has not been considered suitable for dancers to train in other sports to improve their general physical performance¹. At least in adult dancers, classical ballet is a predominantly intermittent type of exercise. During dancing there are periods which can be very energetically demanding, but during dancers' basic training sessions the energy yield is not very high².

In exercise medical literature, there are many reports of delayed sexual maturation and/or menstrual problems in ballet dancers³⁻¹⁰. Because of the physiological and perhaps aesthetic demands of ballet, anorexia nervosa is common among female dancers^{8,11-16}. Numerous reports of dance traumatology have been published in recent years^{7,17-30}.

A few studies have been carried out of physical and physiological characteristics of adult dancers^{1,2,31-33}. Claessens *et al.* have described the somatic and motor characteristics of 22 young girls in ballet school³⁴. As far as we know, no studies have been carried out of anthropometric and physiological characteristics of

young boys who train in dance classes. In this report we describe the results of a study of young boys in ballet training, carried out during the Kuopio Dance and Music Festival in Finland in June, 1988.

Material and methods

During the last three years, as part of the Kuopio Dance and Music Festival, a dance course in ballet for boys has been arranged. In 1988, 29 boys aged between 9 to 16 years participated in this two week course during which anthropometric, aerobic and anaerobic power and strength measurements were taken. Two boys were excluded from the final analyses; one had not been dancing for several years, and the other was asthmatic.

The boys had been selected for the course on the basis of their applications. Six of the boys were from the Finnish Opera Ballet School and the remaining had been trained in dancing in different private dancing schools. In general, the boys had started dancing at the age of 8.6 years and had been training for 4.1 years (Table 1). They had, on average, three dance training sessions per week, and the mean time spent on dancing was four hours per week. None of the boys had ever smoked regularly.

Anthropometric measurements were taken using routine methods. Height and weight were measured and the body mass index (BMI) expressed as $\text{kg}\cdot\text{m}^{-2}$, was calculated. Thickness of four skinfolds (biceps, triceps, subscapular and suprailiac) was measured with Lange skinfold calipers (Cambridge Scientific Industries, Inc., Cambridge, Maryland) and the sum of the skinfolds was calculated. The degrees of lumbar lordosis and thoracic kyphosis were determined using a spinal pantograph³⁵. Flexibility was measured with the Wells Sit and Reach Test, but using Camaione modification in which flexibility can be measured in standing position (stand and reach)³⁶.

The boys were divided into two groups according to sexual maturity by Tanner's scale³⁷. If there were no signs of the pubic hair (Tanner classification $P = 1$) the boy was considered to be prepubertal, otherwise, ($P = 2$ or greater) he was considered to be pubertal. This assessment was made during the medical examination prior to physical performance tests.

Maximal aerobic power was assessed by cycle ergometry, using an electrically braked ergometer (Siemens Elema, Sweden). Oxygen uptake was measured with a Medikro 202 ergospirometric system (Medikro Ltd, Kuopio, Finland). The analyser was calibrated with room air and against a known gas mixture before each test and calibration checked after each

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Table 1. Activity history of 27 boys (aged 9 to 16 years) training in ballet

	Mean±SD	Range
Beginning age (yr)	8.6±1.6	4.0–13.5
Years in training	4.1±2.3	0.6–11.1
Sessions per week	3.1±1.5	1–6
Hours per week	4.2±2.7	1.0–9.0
Other exercise (h·week ⁻¹)	1.8±2.3	0–9.0

test. After three minutes of warming-up with a work load of one Watt per kg body weight, the work load was increased 20 Watts every minute until voluntary exhaustion. During the test, strong verbal encouragement was given to achieve maximum effort.

Peak oxygen uptake was registered as maximal oxygen uptake (VO₂max, STPD). Maximal production of carbon dioxide and maximal ventilation (V_Emax, BTPS) were also registered. Maximal heart rate (HRmax) was measured from the continuously monitored ECG.

A jumping test was used to measure explosive strength and anaerobic power. The Ergo Jump-system (Digitest Ltd, Muurame, Finland) in which a digital timer is concentrated by a cable to a resistive platform was used. The flight times in single jumps (both static jump, T₁ static, and explosive stretch-shortening type of exercise, T₁ elastic) were measured and the displacement of centre of gravity (DCG) was calculated according to Bosco *et al.*³⁸. Anaerobic power (mechanical power in jumping, P₃₀) was calculated from the flight time in a series of 30 jumps according to the formula presented by Luhtanen³⁹. The flight times after both 10 and 20 jumps were also registered and the corresponding powers (P₁₀, P₂₀) were calculated.

The cycle ergometer and jumping tests were performed on separate days. In the analyses of the results, mean values of prepubertal and pubertal boys were compared. The statistical comparison was made with student's t-test.

Results

Physical characteristics of the boys are presented in Table 2. The mean ages of prepubertal and pubertal groups were 11.1 and 14.1 years respectively. As expected, pubertal boys were taller and weighed more ($p < 0.001$) than the prepubertal ones. In BMI and sum of four skinfolds the differences were statistically not significant. Also the differences in thoracic kyphosis or lumbar lordosis were not statistically significant. In stand and reach test, pubertal boys got their fingers on the average 15 cm below their toes, while in prepubertal boys the result was 10 cm ($p < 0.01$).

Except for HRmax and RQmax (maximum respiratory quotient), pubertal boys reached significantly higher values in cycle ergometer test than prepubertal boys (Table 3). The mean VO₂ max (ml·kg⁻¹·min⁻¹) was 56 in pubertal and 47 in prepubertal boys ($p < 0.001$). In jumping tests, all the results were significantly higher in pubertal than in prepubertal boys (Table 4). The mean displacement of centre of gravity (DCG) in the static jump was 0.35 m in pubertal and 0.27 m in

Table 2. Physical characteristics of young boys training in ballet (mean±SD, range in parenthesis) in two groups (prepubertal, Tanner P = 1, and pubertal, Tanner P > 1)

	Prepubertal n = 13	Pubertal n = 14	p < *
Age (yr)	11.1±1.1 (9.0–13.4)	14.1±1.7 (10.6–16.2)	0.001
Height (cm)	143±6 (131–157)	162±9 (148–172)	0.001
Weight (kg)	34.3±6.5 (27.3–50.8)	47.0±7.7 (32.8–58.5)	0.001
BMI (kg·m ⁻²)	16.7±2.5 (14.3–24.0)	17.8±1.4 (15.0–20.0)	ns
Skinfolds (mm)**	40±25 (23–118)	26±8 (16–51)	ns
Thoracic kyphosis (degrees)	33±9 (17–47)	35±7 (26–52)	ns
Lumbar lordosis (degrees)	40±12 (26–69)	34±11 (16–51)	ns
Stand and reach (cm)*** (flexibility)	10±5 (1–17)	15±5 (7–22)	0.01

* student's t-test

** sum of four skinfolds (biceps, triceps, subscapular, suprailiac)

*** below the toe level

Table 3. Results of the cycle exercise tests in 27 boys training in ballet

	Prepubertal n = 13	Pubertal n = 14	p < *
Maximal workload (W)	145±23	229±44	0.001
(W·kg ⁻¹)	4.2±0.5	4.8±0.3	0.01
VO ₂ max (l·min ⁻¹)	1.62±0.34	2.65±0.56	0.001
(ml·kg ⁻¹ ·min ⁻¹)	47±6	56±4	0.001
HRmax (beats·min ⁻¹)	192±11	199±6	ns
V _E max (l·min ⁻¹)	68±14	108±23	0.001
RQmax	1.16±0.07	1.20±0.05	ns

*student's t-test

Table 4. Results of the jumping tests in 27 boys training in ballet

	Prepubertal n = 13	Pubertal n = 14	p < *
T ₁ static (s)	0.47±0.04	0.53±0.04	0.01
DCG** static (m)	0.27±0.04	0.35±0.05	0.01
T ₁ elastic (s)	0.48±0.04	0.56±0.04	0.001
DCG** elastic (m)	0.29±0.05	0.38±0.06	0.001
Power ₁₀ *** (W·kg ⁻¹)	10.1±0.8	11.4±1.1	0.01
Power ₂₀ *** (W·kg ⁻¹)	9.8±0.7	11.1±1.0	0.01
Power ₃₀ *** (W·kg ⁻¹)	9.5±0.6	10.7±0.9	0.001

* student's t-test

** displacement of centre of gravity

*** mechanical power in a series of 10, 20 and 30 jumps; calculated according to formula³⁹

$$P = \frac{g^2 \cdot t}{4n} \quad t = \text{flight time (s)}$$

$$g = 9.81 \text{ m} \cdot \text{s}^{-2}$$

$$n = \text{number of jumps}$$

Table 5. Selected data from some previous studies in which athletic and non-athletic boys have been measured

Variables	Mean values	Subjects	Age groups	Reference
Skinfold thickness (mm)	27–31	X-c ¹ skiers	10 to 14	Pekkarinen and Mahlamäki ⁴⁵
	30–44	School boys	10 to 14	Pekkarinen and Mahlamäki ⁴⁵
Thoracic kyphosis (degrees)	31–37	X-c skiers	12 to 14	Mahlamäki and Pekkarinen ⁴⁵
	29–37	School boys	12 to 14	Willner and Johnsson ⁴⁶
Lumbar lordosis (degrees)	39–37	X-c skiers	12 to 14	Mahlamäki and Pekkarinen ⁴⁵
	32–35	School boys	12 to 14	Willner and Johnsson ⁴⁶
VO ₂ max (ml·kg ⁻¹ ·min ⁻¹)	59–65	X-c skiers	11 to 15	Pekkarinen ⁵³
	56–61	School boys	11 to 15	Pekkarinen ⁵³
	52–61	School boys	11 to 15	Rutenfranz <i>et al.</i> ⁴⁹
	49–52	School boys	11 to 15	Cunningham <i>et al.</i> ⁵⁰
	50–52	School boys	12 to 15	Eynde <i>et al.</i> ⁵¹
Power, jumping test (W·kg ⁻¹)	22	School boys	17	Bosco <i>et al.</i> ³⁸
Power, Wingate test (W·kg ⁻¹)	7	School boys	17	Bosco <i>et al.</i> ³⁸
	7–8	School boys (9-week training)	10 to 12	Rostein <i>et al.</i> ⁵⁴
	7–8	Active boys ² (4-week training)	12	Docherty <i>et al.</i> ⁵³

¹ Cross-country² Hockey and soccer players

prepubertal boys ($p < 0.01$). The elastic component improved DCG on the average by 0.03 m in pubertal and 0.02 m in prepubertal boys. The mean mechanical power after 30 jumps was 10.7 W·kg⁻¹ in pubertal and 9.5 W·kg⁻¹ in prepubertal boys ($p < 0.001$).

Discussion

Young male athletes more often than not tend to be maturationally advanced compared with non-athletes⁴⁰. Young ice hockey players⁴⁰ and schoolboy gymnasts⁴¹ may be slightly delayed in maturation. Because of the cross-sectional nature of this study it is difficult to decide whether the maturation in ballet trained boys is delayed or advanced. Finnish boys reach Tanner stage G2 on the average of 12.2 years⁴². Thirteen of the boys in the present study were younger than that. When looking at the remaining 14 boys, seven of them (50 per cent) seemed to be slightly delayed in sexual maturity in comparison to average according to Ojajarvi⁴².

In sports, young male gymnasts seem to be shorter than average^{40,41}. In general, the height and weight of the boys in this study were slightly less than the average noticed in recent Finnish studies^{42,43}.

Also more than half (15/27, 56 per cent) of these boys were reported to be among the shorter ones in their ordinary school classes. Eleven of the 27 boys (41 per cent) were among the shortest three. Only six boys (22 per cent) were taller than average. In the study of Claessens *et al.*, mean values for height and weight in ballet girls were below the mean of the reference group, and none of the 22 ballet girls had a value above the mean of their respective reference data for weight³⁴.

According to the present study, it could be said, perhaps, that one of the typical characteristics also in

young male ballet dancers is a body size slightly smaller than the average. In the study of Cohen *et al.*, adult male and female dancers were slightly taller but weighed less and had significantly smaller bony diameters and body circumferences than the controls³³.

In the stand and reach test, all the dancers reached at least the toe level. The flexibility of boy dancers seem to be better than the average in these age groups⁴⁴. A high degree of flexibility was observed also in ballet girls studied by Claessens *et al.*³⁴.

Table 5 is a summary of some previous studies in which young boys have been measured. Relative leanness also seems to be typical for dancing boys. Except for one prepubertal boy who had a large sum of four skinfolds (118 mm), the others had quite low values of skinfold thickness. In general, the sums of four skinfolds were quite similar to those found in young endurance training athletes⁴⁵.

The mean degrees of the sagittal spinal curves (thoracic kyphosis and lumbar lordosis) of these young male dancers were of the same magnitude as found in teenagers elsewhere^{46,47}. According to our experience, however, in female dancers of the same age, straightened spinal curves can be found. It is possible that dance teachers select girls with straight spines for dance classes. Because of the smaller number of boys in dance classes, such a selection is not possible.

The VO₂max in adult male dancers was reported as 56 ml·kg⁻¹·min⁻¹ and in female dancers 51 to 53 ml·kg⁻¹·min⁻¹^{1,2}. These values are low, especially in men, when compared to endurance trained athletes^{48,49}.

In prepubertal boy dancers maximal workload and VO₂max were less than in both cross-country (x-c) skier and control boys studied by Pekkarinen³⁴. One of the prepubertal boys weighed 50.8 kg, but even his exclusion did not increase the mean VO₂max (47

ml·kg⁻¹·min⁻¹). In pubertal boys, the values were clearly less than in x-c skier boys, but about similar to those in control boys. Also in comparison to some other studies made in ordinary boys of similar age, VO₂max in prepubertal boy dancers is somewhat lower, but about similar in magnitude in pubertal boy dancers⁵⁰⁻⁵². It is notable that almost half the boy dancers (five prepubertal and seven pubertal) did not train in any other sports. It seems that in those boys who begin to dance ballet the maximal aerobic power is not very high and even in more highly trained boy dancers it is only on average.

Kirkendall and Street found that adult ballet dancers generated significantly less mechanical power than bobsled, indoor soccer and basketball athletes⁵². In our study, both the flight time in static jump and the mechanical power in both prepubertal and pubertal dancer boys were slightly higher than in x-c skier boys studied similarly by Pekkarinen⁵⁴. Bosco *et al.* found that the mechanical power calculated from the jumping test is about three times higher than in a modified Wingate anaerobic test³⁸. In adolescent schoolboys their mean values were 22.2 and 7.1 W·kg⁻¹ respectively³⁸. In other studies in younger boys, mean values in the Wingate test have been about 7 to 8 W·kg⁻¹^{53,55}. In our jumping test, the power values were higher (10 to 11 W·kg⁻¹), but because of the different formula, the values are less than those reported by Bosco *et al.*³⁸.

It is possible that the special training in ballet has affected those muscle characteristics in dancing boys. Cohen *et al.* called dancers a group of highly trained non-endurance athletes³³. After taking muscle biopsies from female dancers, Dahlström *et al.* noticed, however, that the dancers had a high percentage of type I fibres, similar to endurance-trained female runners and cross-country skiers¹. They concluded that the high percentage of type I fibres may be the result of selection. Except for the mechanical behaviour of skeletal muscles, the jumping test also taxes the anaerobic energy conversion system³⁸. Our results indicate that, rather than having the potential for aerobic performance, boy dancers may have better anaerobic capacity than boys who train for endurance.

In conclusion, a relatively small body size, moderate subcutaneous fat, relatively high flexibility, only moderate maximal aerobic power, but relatively good explosive strength and anaerobic power in leg muscles, are typical for boys who train in ballet.

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