STRUCTURE OF MUSCLE STRENGTH AMONG PROFESSIONAL CLASSICAL FEMALE DANCERS

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The work characterizes in detail the level of static torques in classical ballet female dancers, in comparison to their peers, students of physiotherapy at the University of Medical Sciences. The analysis of torques consisted in evaluation of 13 functional muscle groups (11 groups of left and right extremities and 2 of the trunk). Apart from few exceptions, the tested dancers were stronger, however the difference was not always statistically significant.

KEY WORDS: muscle torques, strength asymmetry.

Abbreviations

AV – average value
H [m] – body height
BMI [kg•m-2] – body mass index
m [kg] – body mass
LE – lower extremity
UE – upper extremity
M [Nm] – muscle torque
MADF – torque of ankle dorsal flexors
MAPF – torque of ankle plantar flexors
MEF – torque of elbow flexors
MEE – torque of elbow extensors
MHF – torque of hip flexors
MHE – torque of hip extensors
AFA – academy of fine arts
USPE – university school of physical education
MHADD - torque of hip adductors
MHABD – torque of hip abductors
MKF – torque of knee flexors
MKE – torque of knee extensors
MTF – torque of trunk flexors
MTE – torque of trunk extensors
MGTF- torque of great toe flexors
SD – standard deviation
V – coefficient of variance
UMS – university of medical sciences

INTRODUCTION: The specificity of dance training consists in many hours of repeating choreographic elements in vertical position, in compulsory and unnatural arrangement of lower extremities. Most "figures" include a maximum external rotation of the hip joint. Many expressive movement tasks of dancers consist of jumps which, especially in the landing phase, generate large dynamic overloads that may reach 9.4 BW. They cause various unpleasant injuries, sometimes permanent (Brüggemann 1994, Dworak et al. 2005). That is why high level of motoric preparation of dancers, with special attention to the level of muscle strength, is a significant issue.

The limited scope of this paper makes a broad analysis of the state of knowledge impossible. We are going to quote only a few works that aim at evaluating values of forces and moments of forces in muscles.

Swanenburg et al. (2003), after examining 24 46-years-old women, defined maximum force of flexors of the hallux in metatarsophalangeal joint at the level of 109.8 N for the right foot and 129.2 N for the left one. Bennell et al. (2001), in comparison to a control group, studied changes of strength in flexors, rotators, adductors and abductors of hip joints in 8-11 years old female ballet dancers within a yearly class cycle. They discovered a faster increase in strength in ballet dancers. Thomas et al. (2004) compared static and dynamic characteristics of torque of plantar flexors in non-dancers, folk dancers and ballet dancers. The non-dancers were significantly weaker.

This paper forms a part of a large research project carried out in form of a research grant. The project concerns the biomechanical profile of professional dancers.

Purpose of the study: The purpose of this study is to identify torques generated in static conditions in selected muscle groups of professional female dancers in order to describe their force profile.

Specific aims of this paper are expressed in the following tasks:

- describing the level and topography of muscle torques generated by extensors and flexors of the trunk, elbow joints, hip joints, knee joints, upper ankle joints, great toe flexors, hip joint adductors and abductors;
- describing degree of asymmetry of the tested torques of left and right extremities;
- comparing the tested torques of the dancers with the results of the control group (physiotherapy female students of UMS);
- answering the question concerning the level of physical preparation of dancers against potential injuries.

MATERIAL AND METHODS: The study included 14 ballet dancers of the Opera House in Poznań. The comparative group included 38 female students of physiotherapy of the University of Medical Sciences in Poznań, all of moderate recreational level of activity. The research was approved by the bioethical commission and all subjects expressed their will to take part in the tests in a written form.
Detailed anthropometric data of the tested groups is presented in table 1.

Table1 Anthropometric data of the tested dancers and students

PARAMETERS	Dancers			Controls		
	AV	SD	V[%]	AV	SD	V[%]
Age [years]	23.6	3.7	15.7	21.1	0.6	2.8
Body mass [kg]	53.6	5.1	9.5	57.5	7.2	12.5
Body height [cm]	170.5	5.1	2.3	167.9	5.5	3.3
BMI [$kg \cdot m^{-2}$]	18.4	1.0	5.4	20.4	2.0	9.8

The dancers were approximately 10 % older than the students of the control group. They differed significantly in the BMI value.
After a standard warm-up muscle torques were tested, according to a standard protocol in static conditions, on special measurement stands equipped with strain gauge transducers. During the measurements the body segments affected by the tested muscle groups were arranged in vertical position, hence eliminating the static torques.
The measurements were continued until maximum force was recorded. These values were then qualified for further statistic study. All subjects consented to take part in the experiments. The applied methods were described in detail in the works of Dworak (1990) and Dworak et al. (2003).
The force values were measured with the accuracy of up to 0.1%, and the moment arm up to 1%.
The analysis of the results was carried out using descriptional statistics, whereas statistic significance of the differences was evaluated on the basis of the U Mann-Whitney and Wilcoxon tests.

RESULTS AND DISCUSSION: The results of the tests are presented in table 2.
Due to significant differences in body mass of the dancers and the control group (7.3%), absolute values of M [Nm] were analyzed in detail.
Muscle torques
The analysis of the results presented in table 2 leads to the formulation of the following observations. On the basis of sums of absolute and relative torque values (Σ MEF+MEE, Σ, Σ MTF+MTE and total ΣM) one can observe that the tested dancers were stronger. The differences of the total ΣM coefficient equaled 7.5 and 14.5 %, respectively. Lower extremities which are especially important in the dancers' profession, were also stronger in

view of the tested torques Σ M by approximately 9 and 16%. The greatest differences in the absolute values of torques in favor of the dancers concerned hip extensors (20-22%) and ankle dorsal flexors (14.2 and 19%). Statistically significant differences ($p<0.05$) concerned the following muscle groups: HE, HADDR, ADFR.

Table 2 Mean values and SD of absolute and relative torques of examined muscle groups of hands-legs-trunk of dancers and controls

PARAMETERS			**Absolute M values [Nm]**		**Relative M values [Nm/kg]**	
			Dancers	**Controls**	**Dancers**	**Controls**
UPPER EXTREMITY	MEF	L	37.3±5.9	35.5±5.4	0.70±0.09	0.62±0.07
		R	39.2±7.3	36.1±6.7	0.73±0.11	0.63±0.10
	MEE	L	22.1±4.0	21.0±3.3	0.41±0.07	0.37±0.05
		R	23.2±4.3	21.9±3.0	0.43±0.07	0.38±0.04
Σ MEF+MEE		-	121.8±20.5	113.5±18.4	2.27±0.34	2.00±0.26
LOWER EXTREMITY	MHF	L	134.6±26.7	122.4±26.8	2.50±0.38	2.13±0.37
		R	136.6±27.7	126.3±21.5	2.56±0.49	2.20±0.29
	MHE	L	132.5±27.6	105.2±26.3	2.47±0.43	1.83±0.39
		R	137.5±26.8	107.4±23.0	2.57±0.48	1.87±0.34
	MHADD	L	86.9±14.8	84.6±17.6	1.64±0.32	1.40±0.29
		R	90.7±24.1	96.7±22.7	1.71±0.48	1.60±0.29
	MHABD	L	102.7±26.0	94.7±25.6	1.94±0.53	1.55±0.31
		R	107.8±36.4	81.6±20.1	2.02±0.67	1.36±0.34
	MKF	L	91.2±15.3	86.7±19.9	1.70±0.24	1.51±0.33
		R	99.7±37.1	89.4±20.4	1.86±0.65	1.55±0.30
	MKE	L	160.3±30.7	155.6±31.7	2.98±0.42	2.71±0.45
		R	168.1±27.0	159.9±31.4	3.14±0.40	2.79±0.54
	MADF	L	40.0±8.9	34.3±11.8	0.74±0.15	0.60±0.19
		R	41.2±9.3	33.4±11.9	0.77±0.15	0.58±0.18
	MAPF	L	177.3±41.9	168.7±38.6	3.32±0.75	2.95±0.62
		R	182.2±40.9	170.6±33.6	3.42±0.79	2.98±0.58
	MGTF	L	9.4±2.6	10.7±1.7	0.18±0.05	0.18±0.03
		R	9.8±2.5	11.8±2.8	0.19±0.06	0.19±0.05
Σ		-	1908.6±426.2	1739.9±387.4	35.71±7.78	29.98±5.89
TRUNK	MTF	-	127.0±27.4	122.2±31.4	2.37±0.47	2.14±0.59
	MTE	-	200.8±35.0	205.4±32.7	3.74±0.55	3.59±0.55
Σ MTF+MTE		-	327.8±62.4	327.6±64.1	6.11±1.02	5.73±1.14
Total ΣM		**-**	**2358.1±510.1**	**2181.0±469.9**	**44.09±9.14**	**37.71±7.29**

In some cases, unexpectedly for the authors, students were stronger than the dancers. This included the following muscle groups: HADDR (6.5%), GTFL&R (14.7% and 16.7%), and TE (2.3%). Such great differences in torque of the great toe flexors (in favor of the students) were especially surprising - however these were not statistically significant. One may observe that statistically significant differences in absolute values occurred in most of the tested muscle groups, except: HADD, KFR, ADF, GTF, TF and TE.

During the analysis of the degree of asymmetry of the torque values, the researchers observed that the dancers always possessed stronger right extremity muscles. One exception in the control group were the left hip abductors (HABDL). Statistically significant asymmetry of the forces in dancers concerned only muscles of the trunk extensors and flexors. Significant asymmetry of the forces in the control group concerned as much as five muscle groups: EE, HABD, HADD, TF and TE.

Comparing some of the results of the researchers' own tests with the data published in literature (concerning lower extremity muscles), the following similarities and differences were observed. The study of Buśko (1997) concerning female basketball players of similar age indicated that the dancers have weaker knee extensors by approx. 9.6% and similarly flexors by 9.7%. The research of Trzaskoma & Trzaskoma (1999) on athletes showed that

summary values of torques of knee extensors and flexors in dancers compared to professional athletes were lower by as much as approx. 53%. The ratio of relative values MHE+MHE was at 5.0:9.9 Nm/kg. Finally, the study of Thomas (2004) on 21 young female students practicing no exercise apart from folk dance and ballet demonstrated that isometric peak torque values of our tested dancers were higher than in the students practicing ballet dance by approx. 51%.

CONCLUSION: This paper presents in detail the level of static forces and torques in classical ballet dancers of the Opera House in Poznań. The analysis of torques consisted of evaluating 13 functional muscle groups. The results of the tests on dancers were compared with those of their peer students of physiotherapy. Except for a few muscle groups, professional dancers (ballet dancers) were stronger. However, statistically significant differences concerned only three muscle groups: hip extensors, right adductors and right ankle dorsal flexors.
Research of similar character will be continued on professional modern dancers, employing different movement techniques and training methods.

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