RELATIONSHIP BETWEEN MUSCLE TORQUE AND BODY WEIGHT IN MEN

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INTRODUCTION

The relationship between body weight and muscle torque expressed in the title of the paper is significant and rather well know. The scale in some of the physical fitness tests for children is based on this relationship. In such sports as weight lifting, boxing, judo and wrestling the above mentioned relationship is the reason for making weight categories. In such a way the relative value of sports result is acknowledged, that is the champion of a given weight category is accepted as well as the all-weight champion. Changes in the muscle torque level are taken for the index of the competitor's progress (JUSKIEVITSCH and PETRIKIEVITSH, 1984) or the measurement of the torque of the different muscle groups is used as the indication for selection to sports (JASZCZUK et al., 1988). The purpose of the paper is to extend the above-mentioned ideas and to outline the relationship between body weight and muscle torque in its different aspects such as absolute and relative torque and static and dynamic torque. In the sports pratice and physical fitness tests the term stregth is most commonly used whereas the correct measurement applies to torque of the muscle groups. In addition, when the muscular stregth of a given subject is considered it is advised to make such characteristic of a possible numerous muscle groups in spite of the more or less significant correlation between them (JASZCZUK et. al., 1987, DWORAK 1989).

MATERIAL AND METHOD

Torques of eight muscle groups of the major joints of upper and lower extremities (right side) were measured for this project. Twenty two male subjects, skilled but not competitive sportsmen at the age from 18 to 38 (x=25+5.63 years) were investigated. Torque measurement was undertaken using MERAC machine produced by Universal Gym Equipment (Cedar Rapids, Iowa). The static torque that is at maximum voluntary contraction at the optimal joint angle (BOBER and HAY,1990) (MVC) and the concentric contraction torque in isokinetic mode (IKN) at speed 1rad/s of flexor and extensor groups of elbow, shoulder, knee and hip joints were measured. The sum of eight muscle groups in static condition (ΣMVC) was taken to represent the absolute static muscle torques of the subject. The sum of the concentric peak torque of the same muscle groups and the same angular positions like in static condition was taken to represent the absolute isokinetic torque (ΣIKN) of the subject. The above torques divided by body weight made up the relative static torque (ΣMVC/BW) and relative isokinetic torque (ΣIKN/BW) respectively. Basic statistics were applied to these data.

RESULTS

The basic characteristics of the subjects including mean and standard deviations of the sum of eight muscle (groups) as the static and isokinetic (torques and their) relative values are in Table 1. The mean age of the investigated group suggests that in relation to the strength development they are in the optimal age category, however the range of age from 18 to 37 years is rather large. According to LARSON et al. (1979) men who are under 20 years old are evidently weaker than men at the age of 20 to 30, who in turn are not significantly stronger than men at the age of 30 to 39. These data refer to isometric and isokinetic at 60°/sec torques as well. With men over 50 years old the strength level is significantly decreasing (LARSON et al., 1979, MURRAY et al., 1980).

TABLE 1
Body weight and muscle torque

	units	$\bar{x}$	Sx	min	max
Body Weight	kg	78.77	14.55	64	118
Body Height	cm	179.14	6.59	168	193
Rohrer Index		1.358	0.175	1.09	1.73
ΣMVC	Nm	1120.50	227.79	872	1765
ΣIKN (1 rad/sec)	Nm	896.50	165.19	518	1170
ΣMVC/BW	Nm/kg	15.69	2.59	9.91	20.52
ΣIKN/BW	Nm/kg	11.21	2.08	7.00	14.41

In the investigated group the significant negative correlations between age and ΣMVC and ΣIKN have been found (r= -0.62 and -0.59 respectively). Such result can be explained not only because the strength decreases with aging but also by the physical activity of the subject. All of them were considered as active participants in recreational sports but the younger prefered weight lifting and other body building exercises to running and swimming which were practiced by older subjects. The correlation between age and body weight showed the same negative tendency but was statistically nonsignificant (r= -0.29).

The Rohrer Index,

$$RI = \frac{\text{BODY WEIGHT (g)}}{\text{BODY HEIGHT (cm)}} * 100$$

was used to make up the general characteristics of subject, which comprised both weight and height of the body. Such index was proposed by CURTIUS (MALINOWSKI and STRZALKA, 1985) to distinguish the somatotypes. According to this author our group represented the athletic type, which comprises within 1.23-1.48 of the index. Below this limit is leptosome (there were such subjects) and above, pyknic somatotype (six subjects).

The static torque (ΣMVC) of our group can be compared to the data of young athletes and of the same muscle groups published by JASZCUK at al. (1987). According to their findings the torque of shooters was 1182 Nm, wrestlers free style 1289 Nm and fencers 1327 Nm, and were similar to our subjects. Much stronger than our group were weight lifters (1568 Nm) and judo athletes (1580 Nm). It is worth to emphasize that these data concerned young but selected Polish athletes (mean age of the group between 17 and 18 years).

TABLE 2
Correlation coefficients between body weight (BW) and Rohrer Index and absolute and relative torques

	Absolute torque		Relative torque	
	MVC	IKN	MVC	IKN
BW	.52**	.41*	-.42*	-.46*
Rohrer Index	.39	.31	-.31	-.49*

statisticaly significant: (**) at 1% and (*) 5% level of confidence

The correlation coefficients between body weight and Rohrer Index, and results absolute and relative torque are in Table 2. It appears, that all torque results correlate significantly, at least at 5% of confidence, with body weight. The correlation coefficients between Rohrer Index and torques have the same tendency as the previous ones but are statisticaly nonsignificant. Because of the known nonlinear relationship between body weight and muscular strength (ZACIORSKI, 1970) the search for polynomial equations of the relatively low order but fitting well to empirical data was undertaken. The nonlinear relationship between body weight and absolute and relative torques (static and isokinetic) are shown in Figure 1 and 2. The investigated relationships presented in these figures are well described with the quadratic equations. The absolute isokinetic torque is

smaler by about 30% than absolute static torque. The maximum of the isokinetic torque is at about 95 kg of body weight whereas the static one at 100-105 kg of body weight. The relative torque has its maximum at 65 kg (IKN) and 70 kg (MVC) but at the weight equal 120 kg it is only three fourths of the maximum value. Figures 3 and 4 show absolute and relative torques of static and isokinetic modes in a function of Rohrer Index. The presented nonlinear approach for investigation of the relationship between Rohrer Index and relative strehgth showed no better result than the simple correlation (Tab.2).

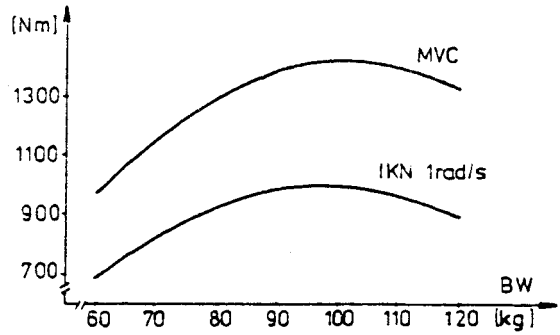

Figure 1: Absolute torque [Nm] in static (MVC) and isokinetic (IKN) modes in a function of body weight (BW).

$MVC = -1252.65 + 52.38x - 0.26x^2$ R = 0.682
$IKN = -1060.69 + 41.82x - 0.21x^2$ R = 0.698

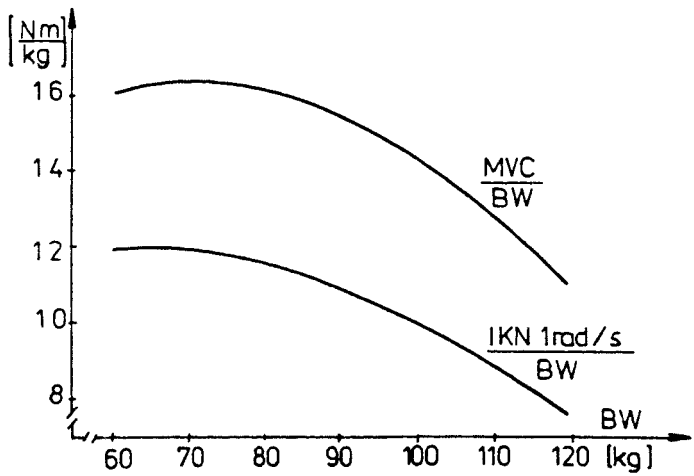

Figure 2: Relative torque [Nm/kg] in static (MVC/BW) and isokinetic (IKN/BW) modes in a function of body weight (BW)

$MVC/BW = 5.16 + 0.32x - 0.002x^2$ R = 0.716
$IKN/BW = 6.15 + 0.18x - 0.001x^2$ R = 0.792

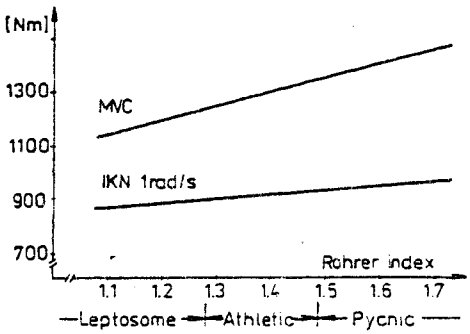

Figure 3: Absolute torque [Nm] in static (MVC) and isokinetic (IKN) modes in a function of Rohrer Index.

MVC = 559.84 + 529.84x r = 0.39
IKN = 637.32 + 174.07x r = 0.31

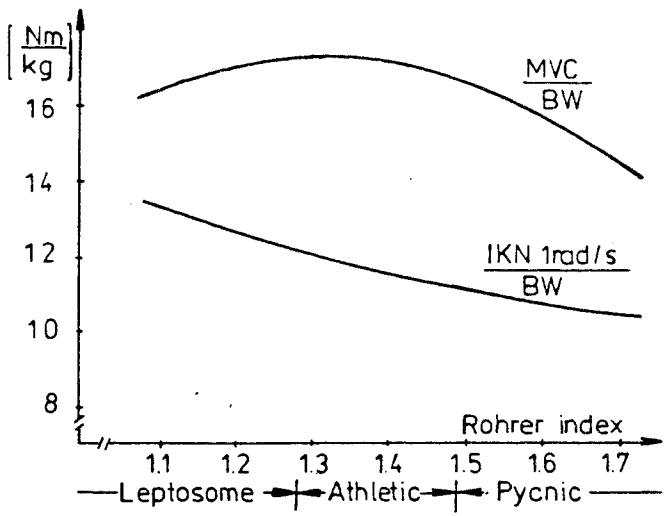

Figure 4: Relative torque [Nm/kg] in static (MVC/BW) and isokinetic (IKN/BW) modes in a function of Rohrer Index.

$MVC/BW = -14.51 + 48.23x - 18.31x^2$ R = 0.374
$IKN/BW = 18.76 + 5.44x - 0.226x^2$ R = 0.559

INTERPRETATION AND CONCLUSION

The relationship between body weight and torque of the eight muscle groups crossing transverse axes of elbow, shoulder, knee and hip joints provided result being to some extend a model of this phenomenon. The correlation between age and torque was significant and negative in this group of men. Such general tendency as progress of strength with age in children and young people, then high level and relative stable strength until the age of about 50 and then significant decrease of torque probably must have the additional cause in the difference of physical activity between younger (20-25 years old) and older subjects in favor of the former. On the other hand, the significant positive correlation between age and strength in young 15 and 21 years old was the reason to eliminate the age factor from the body weight - torque relationship used as the synthetic index for the sport practice (JASZCZUK et al., 1988). To change the nonlinear relationship between body weight and torque into linear one, these authors transformed the data into logarithmic scale. The measurement of torque of muscle groups is used in sport to control the training process or to investigate the relationship between strength and sports technique. The daily, weekly and yearly changes in muscular stregth have also been investigated (WIT, 1980). For such purposes the torques in statistic condition were measured most frequently. One can conclude from our data that the isokinetic torque in concentric contraction and at low speed provide similar information. The high isokinetic speed 6-10 rad/s may change this relationship. The same may happen when the torque characteristic of man is based on date for a single muscle group. The other problem is to use relative instead of absolute torque. When absolute torque index is considered the interpretation based on relationship between body weight and mass of muscular system. The high percentage of muscles up to 50 % in the total body weight is typical for young men practising physical exercises and such was the case with our subjects. The relationship between absolute torque and body weight can be used as one of the indexes in selection to sport in which the division into weight categories is not practiced as for example in throwing events. The relative torque expresses the muscle efficiency, however it is based on total body weight but not on the mass of muscles. The relative torque in a function of body weight shows its maximum at the weight of 60-70 kg. Men of such weight have the most efficient muscles in terms of strength. This kind of information can be useful for testing athletes in sports where competitors are divided into weight categories.

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