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FUNDAMENTAL MOVEMENT ASSESSMENT OF YOUNG FEMALE GYMNASTS

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The purpose of this study was to identify physical and motor skills of talent identified female gymnasts. Sixteen gymnasts aged five to eight years completed anthropometry, movement ABC, flexibility, strength, and jumping tests. Movement ABC testing revealed that whilst none of the gymnasts were motor impaired, strong fundamental motor skills can't be assumed except for in the area of static balance. A number of the anthropometric, physiological and biomechanical test results revealed significant age effects which would therefore require large normative data sets for reliability. With the exception of anthropometry, other tests results (excluding those affected by age) showed large variation across the group. Follow-up research is needed to determine whether the tests with large group variation can identify the child with Olympic gymnastics potential.

KEY WORDS: talent, gymnastics, movement, jump, motor skills.

INTRODUCTION: Talent identification in gymnastics is widely employed to select children who have potential to excel in the sport. To select children at an early age (usually 4 to 6 years), talent is typically selected using body shape and physical assessments. The ideal gymnast is commonly described as below average height and body mass, petite body frame with broad shoulders, narrow hips, long arms, short torso and well defined, thin limbs. In addition to the ideal anthropometric profile the gymnast should be active, have good spatial awareness, strong balance skills, and excellent coordination. The current talent identification programs therefore largely focus upon the subjective selection of potentially talented children. Identifying children based on subjective anthropometric, performance and physiological attributes has been reported to be highly variable through childhood and into adolescence (Wolsterncroft *et al.*, 2002). The identification of potential talent should initially be based around assessing the individual's innate or genetic qualities that are most suitable to the sport, with the understanding that the other non-genetic components can be improved through training (Londeree, 1990). The establishment of fundamental motor skills is an essential step in developing sport specific skills (Gallahue & Ozmun, 2006). The assessment of children's gross and fine motor skills may be the key to identifying deficiencies in early skill development and potentially identifying gifted gymnasts. Motor coordination assessment has been recently shown to be able to differentiate between elite and sub-elite gymnasts at ages 6 to 8, and was the single best indicator of performance for 6 year old gymnasts (Vandorpe *et al*., 2011). In addition to the screening of fundamental motor skills, the gymnasts' biomechanical ability when performing those skills is also important. Biomechanical measures that have been linked to gymnastics performance potential include, for example, squat jump force and power (Bradshaw & Le Rossignol, 2004) and rebound jump displacement (McNeal & Sands, 2001). Talent identification programs which focus on only one or two major areas such as body shape can often exclude or misidentify potentially talented athletes. This could result in one-dimensional, incomplete or a misdirected testing battery (Abbott & Collins, 2004). The purpose of this research was therefore to assess pre competitive talent identified gymnasts' anthropometry, sport specific strength, flexibility, motor skills and jumping ability to identify the specific characteristics which talent identified gymnasts possess.

METHODS: Sixteen pre-competitive, talent-identified female gymnasts aged five to eight years (Height = 120.92 ± 5.34 cm; Mass = 20.59 ± 2.29 kg) and who were injury free participated in this study. The gymnasts were part of a junior development squad at a state high performance training centre and were training between five and 20 hours per week (Training = 10.47 ± 4.30 hours). The gymnasts had been participating in gymnastics for 13.81 ± 11.09 months, of which 8.31 ± 8.28 months was at the present training centre. The study was approved by the university human research ethics committee. Parent consent and gymnast assent was obtained prior to testing. Each gymnasts height, body mass, right sided limb segment lengths, and breadths was measured before they were ask to complete an age appropriate Movement ABC (M-ABC) test battery (e.g. 7-8 year olds – one hand ball bounce and catch, stork balance; Croce et al., 2001; Henderson & Sugden, 1992) to identify potential motor impairment. The gymnasts then completed a modified sit and reach assessment to test hamstring and lumbar flexion (Hoeger & Hopkins, 1992), and a 30 second sit up test to assess torso strength and endurance (Sands, 1993). Biomechanical tests included three trials of a squat jump, countermovement jump, and rebound jumps from box heights of 40 and 70 cm. The jump tests were performed barefoot on a Quattro force platform (Kistler, Winterhur, Switzerland, 500 Hz) covered with two 3 cm thick, high density carpeted foam mats. The average result was recorded for each gymnast from the Quattro jump software (version 1.0.9.2) with forces normalised to units of bodyweight (BW). The raw force-time data for the rebound jumps were exported to a custom written Excel spreadsheet for analysis using the impulse-momentum method (Linthorne, 2001). A V-ratio, arm and leg lengths were calculated from the anthropometric measures consistent with the methods of Bradshaw and Le Rossignol (2004). The average result (from three trials) for each gymnast and measure was collated and analysed using SPSS for Windows software (SPSS Inc., Illinois, version 20.0). An alpha level of 0.05 was set for all analyses. The data was assessed for normality using a Shapiro Wilks test. A one-way analysis of variance (ANOVA) was used to assess the effect of age on the dependent measures that were revealed to be normally distributed, with a Kruskall Wallis test used for those measures that were not normally distributed. The data was further explored descriptively using box-plot analysis to identify outliers and extreme outliers, and to examine the variability by calculating a coefficient of variation (CV%=[Standard Deviation/Mean]x100).

RESULTS: The M-ABC assessment includes both total error scores and percentile ranking with a percentile ranking below 15 indicating motor impairment. The gymnasts achieved an M-ABC score of 1.16 ± 1.89 and a percentile ranking of 78.56 ± 19.12 (minimum = 26th percentile; maximum = 96th percentile). It is not possible to calculate a CV% for the score; however a CV of 24.33% was determined for the M-ABC percentile rank indicating a wide range of motor coordination ability amongst this group of gymnasts. The gymnasts all recorded zero error marks for the static balance tasks. Typical tasks that attracted error marks in some gymnasts were the manual dexterity and ball skill tests.

Table 1: The anthropometry and physiological test results with significant age effects. Layman descriptions for the anthropometric terms are [1]humerus length, [2]femur length, and [3]hip width. Significant age effects identified as *p<0.05 and **p<0.01.

Age (years)	Gymnasts (No.)	Height (cm)*		Acromiale-Radiale (cm)[1]*		Trochanterion to Tibiale (cm)[2]**		Biliocristal Width (cm)[3]*		Sit and Reach (cm)*	
		M	SD	M	SD	M	SD	M	SD	M	SD
5	4	119.8	5.9	19.9	1.4	24.5	1.4	18.2	0.4	25.9	3.2
6	6	118.5	4.4	20.2	1.3	25.6	1.8	18.1	0.3	27.9	2.8
7	2	121.7	2.6	19.2	0.5	26.7	0.2	18.6	0.6	30.8	3.8
8	4	127.2	1.3	22.0	0.7	29.2	1.3	19.6	0.5	32.8	1.5
Group	16	121.4	5.2	20.5	1.4	26.4	2.3	18.6	0.9	29.0	3.7

Many of the test scores were affected by age as outlined in Tables 1 and 2. These included anthropometry measures of height (p=0.043), acromiale-radiale (humerus, p=0.042) and trochanterion to tibiale laterale length (femur, p=0.004), and biliocristal width (hip, p=0.023). Physiological and biomechanical tests were also affected by age, including the sit and reach flexibility test (p=0.020), squat jump force (p=0.049) and impulse (p=0.021), countermovement jump impulse (p=0.027) and displacement (p=0.003), and both 40 (p=0.027) and 70 cm (p=0.039) rebound jump displacement.

Table 2: The biomechanical test results with significant age effects. Significant age effects identified as *p<0.05 and **p<0.01.

Age (years)	Gymnasts (No.)	Squat Jump Take-Off Force (BW)*		Squat Jump Impulse (BW.s)*		Countermovement Jump Impulse (BW.s)*		Countermovement Jump Displacement (cm)**		40 cm Rebound Jump Displacement (cm)*		70 cm Rebound Jump Displacement (cm)*	
		M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
5	4	1.99	0.10	0.18	0.01	0.18	0.02	27.5	3.2	0.1	0.1	0.1	0.1
6	6	1.93	0.11	0.20	0.01	0.20	0.02	27.2	1.5	0.2	0.1	0.1	0.1
7	2	2.00	0.21	0.19	0.00	0.19	0.01	25.2	2.3	0.2	0.1	0.2	0.0
8	4	2.21	0.17	0.22	0.02	0.22	0.02	34.6	3.6	0.3	0.1	0.3	0.1
Group	16	2.02	1.70	0.20	0.02	0.20	0.02	28.9	4.2	0.2	0.1	0.2	0.1

Table 3: The anthropometric, physiological and biomechanical test results without significant age effects where CI is confidence interval, SD is standard deviation, IQR is the inter-quartile range, CV% is the coefficient of variation, and NND is not normally distributed. Significant effects identified as *p<0.05 and **p<0.01.

Measure	Mean	95% CI Lower	95% CI Upper	Median	Variance	SD	IQR	CV%
Mass (kg)	20.7	19.4	22.0	20.8	5.6	2.4	3.7	11.5
Tibiale to Floor Length (kg)^{NND*}	30.9	30.0	31.8	31.7	2.8	1.7	2.4	5.4
Tibiale Mediale to Sphyrion Tibiale Length (cm)^{NND*}	26.1	25.3	26.9	26.4	2.1	1.4	3.1	5.5
Radiale to Stylion Length (cm)^{NND}	16.5	15.9	17.0	16.6	1.0	1.0	1.4	6.0
Leg Length (cm)	57.3	55.3	59.3	58.1	13.4	3.7	6.7	6.4
Arm Length (cm)	36.9	35.7	38.2	37.1	5.1	2.3	8.2	6.1
Biacromiale Width (cm)	27.0	26.4	27.6	27.0	1.2	1.1	1.6	4.0
V Ratio	1.5	1.4	1.5	1.5	0.1	0.1	0.1	3.4
30 sec Sit Up Test (No.)	20.5	18.8	22.2	20.5	9.2	3.0	4.0	14.8
Squat Jump Displacement (cm)	28.6	26.4	30.9	28.2	16.6	4.1	5.3	14.3
Countermovement Jump Take-Off Force (BW)^{NND*}	2.7	2.5	2.9	2.6	0.2	0.4	0.9	16.4
40 cm Rebound Jump Peak Force (BW)^{NND**}	9.5	8.6	10.4	9.8	2.5	1.6	1.8	16.7
40 cm Rebound Jump Contact Time (s)^{NND**}	0.3	0.2	0.3	0.2	0.0	0.1	0.1	40.7
70 cm Rebound Jump Peak Force (BW)^{NND*}	11.9	11.0	12.8	12.6	2.7	1.6	2.2	13.8
70 cm Rebound Jump Contact Time (s)	0.4	0.3	0.4	0.3	0.0	0.1	0.2	37.8

A coefficient of variation was calculated for all test scores that were not affected by age to examine the variance in scores for this group of athletes. With the exception of body mass (CV=11.45%), all of the anthropometric measures showed low variability across the group particularly for the V-ratio (CV=3.42%) which measures the shape of the torso. A score greater than 1.00 indicates that the shoulders are wider than the hips. Greater variation was observed across the group for the physiological and biomechanical test results. The 30 second sit-up test which assesses torso (core) strength and endurance had a CV% of 14.80. Box plot analysis revealed one outlier, an eight year old gymnast whom performed 28.50 sit-ups, which equals almost one sit-up per second. The highest variability observed was contact time during the 40 cm rebound jump (CV=40.74%), followed closely by the 70 cm rebound jump (CV=37.84%).

DISCUSSION AND CONCLUSION: Gymnastics is a complex sport and therefore the profile of an elite gymnast is multifaceted (Prescott, 1999). Movement ABC testing revealed that whilst none of the gymnasts were motor impaired, strong fundamental motor skills can't be assumed except for in the area of static balance. The gymnasts all recorded zero error marks for the static balance tasks which are consistent with previous research that identified that elite gymnasts possess greater balancing ability than other athletes (Hyromalis, 2011). The dynamic tests (e.g. jumping in a square) also revealed moderate to high levels of coordination in these gymnasts. Typical tasks that attracted error marks in some gymnasts were the manual dexterity and ball skill tests. Whilst these motor skills may appear irrelevant to gymnastics, they are applicable to the gymnasts' ability to, for example, perform release and re-grasp skills on the uneven (also known as asymmetric) bars. More generally they relate to the ability to accurately perform whole-body skills supported by the arms and hands on the balance beam and bars. Vandorpe et al. (2012) identified that the Körperkoordinationstest für Kinder (KTK), a similar test battery to M-ABC, best predicted competition results two years later. Well rounded fundamental motor skills may be a pre-requisite for elite gymnastics. A number of the anthropometric, physiological and biomechanical test results revealed significant age effects. These tests such as the sit and reach flexibility test would therefore require large normative data sets of each year of age for reliability. With the exception of measures of height, these tests may also have too much variability during childhood and into adolescence. As flexibility is an important attribute of an elite gymnast an alternative flexibility test may be needed. With the exception of anthropometry, other tests results (excluding those affected by age) showed large variation across the group. Tests that are stable during growth and development years and assess the child's innate or natural talents as opposed to learned responses or training adaptations could have greater ability in identifying talented gymnasts. It is not known whether the tests in this study are assessing the child's natural talents, training adaptations, or a combination of both.

Objective assessment of elite gymnastics potential in young children requires a comprehensive test battery. Whilst subjective assessments of body shape and some anthropometry measures is a common element in talent identification programs, it provides only limited insight on gymnastics potential and should be treated as the first stage of assessment. Follow-up, longitudinal research is needed to determine whether the anthropometry, physiological and biomechanical tests in this study that had large group variation can identify the child with Olympic gymnastics potential.

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