IJSPT

ORIGINAL RESEARCH

MEASURING FITNESS IN FEMALE GYMNASTS: THE GYMNASTICS FUNCTIONAL MEASUREMENT TOOL

Mark D. Sleeper, MS, PT, OCS[1]
Lisa K. Kenyon, PT, PhD, PCS[2]
Ellen Casey, MD[3,4]

ABSTRACT

Purpose/Background: A reliable and valid method of measuring and monitoring a gymnast's total physical fitness level is needed to assist female gymnasts in achieving healthy, injury-free participation in the sport. The Gymnastics Functional Measurement Tool (GFMT) was previously designed as a field-test to assess physical fitness in female competitive gymnasts. The purpose of this study was to further develop the GFMT by establishing a scoring system for individual test items and to initiate the process of establishing the test-retest reliability and construct validity of the GFMT.

Methods: A total of 105 competitive female gymnasts ages 6-18 underwent testing using the GFMT. Fifty of these subjects underwent re-testing one week later in order to assess test-retest reliability. Construct validity was assessed using a simple regression analysis between total GFMT scores and the gymnasts' competition level to calculate the coefficient of determination (r^2). Test-retest reliability was analyzed using Model 1 Intraclass correlation coefficients (ICC). Statistical significance was set at the $p < 0.05$ level.

Results: The relationship between total GFMT scores and subjects' current USAG competitive level was found to be good ($r^2 = 0.60$). Reliability testing of the GFMT total score showed good test-retest reliability over a one week period (ICC = 0.97). Test-retest reliability of the individual component items was good (ICC = 0.80-0.92).

Conclusions: The results of this study provide initial support for the construct validity and test-retest reliability of the GFMT.

[1] Northwestern University, Chicago, Illinois USA
[2] Grand Valley State University, Grand Rapids, Michigan USA
[3] Rehabilitation Institute of Chicago, Chicago, Illinois USA
[4] Northwestern University Feinberg School of Medicine, Chicago, Illinois USA

This study protocol was approved by the Northwestern University Institutional Review Board, Office for the Protection of Research Subjects

Acknowledgements: The authors would like to thank Sarah Baker PT, Michelle Beers PT, Amy Brannon PT, Lilliana de Armas PT, Matthew Erwin PT, Kathleen McGaghie PT, Jamie Meyer PT, Jackie Ostrowski PT, Jaime Passaglia PT, Rachel Plummer PT, Megan Robertson PT, Elizabeth Schornak PT, Mackenzie Strobel PT, and Mark Wildeboer PT for their assistance in collecting data and Karen Hayes PT, PhD for her guidance and advice.

CORRESPONDING AUTHOR

Mark D. Sleeper, MS, PT, OCS
Department of Physical Therapy and Human Movement Sciences
Northwestern University,
645 North Michigan Ave.
Chicago, IL 60611
Email: m-sleeper@northwestern.edu

INTRODUCTION

Women's competitive gymnastics is a multifaceted sport that requires a high level of physical fitness and skill to succeed. Speed,[1-4] strength,[2,3,5,6] endurance,[5] agility,[7] flexibility,[3,8-12] balance,[2,13] and power[8,14-16] are all physical abilities that play a role in the success of a competitive gymnast. A gymnast's physical abilities may also be related to the ability to sustain injury free participation in the sport.[7,17-19] As such, it is imperative that the coaches, trainers, and therapists involved in the sport be able to monitor an individual gymnast's physical abilities and overall fitness level as a means of promoting healthy, injury-free participation in the sport.

Traditionally, field-testing has been done in a variety of sports in an effort to measure sport-specific physical abilities.[20-28] For example, speed, power and agility are physical abilities needed for success in the sport of soccer. Field-tests have been developed in an attempt to quantify each of those physical abilities.[26,29,30] Some field-tests, such as the hop test[31] or the agility T-test,[32] focus on a specific aspect of sport function. Other tests, such as the Functional Movement Screen™ (FMS™),[33,34] include a battery of individual items designed to assess an athlete's abilities across multiple aspects of function.

Within the United States Association of Gymnastics (USAG), a system of competitive levels ranging from a low of 4 to a high of 10 is used to rank the skills and abilities of individual gymnasts. To move from one competitive level to the next, a gymnast must achieve a specific all-around score and be able to perform specific skills that increase in difficulty as the competitive level increases. Individual tests for flexibility, strength, endurance, and power have been suggested as useful tools to gauge gymnastic potential.[35-38] These physical abilities are included in the USAG Talent Opportunity Programs (TOPs) Test, a multi-test battery designed to measure a gymnast's basic skill in addition to the physical abilities of strength, endurance, power, and flexibility.[39] Although the TOPs protocol has changed a number of times since its development by William Sands,[37] it is used primarily with young club gymnasts ages 7-10 years of age to identify competitive potential and aid in the development of the United States competitive gymnastics program. The TOPs was thus not designed to address the needs of gymnasts of all ages or those who compete through high school or collegiate programs. While specialized training is needed to administer the TOPs and the number of people deemed qualified to administer the test is limited, the reliability and validity of the TOPs test have not been reported.

Currently there is not a reliable and valid measurement tool to evaluate the specific physical fitness abilities needed for successful competition in either men's or women's gymnastics. Previous studies have examined possible correlations between a gymnast's level of competition or intensity of training and various singular physical fitness traits.[3,12,40] Nelson and co-workers[3] investigated the relationship between gymnasts' flexibility and strength and varying training intensity levels. The gymnasts at the highest level of training were reported to be the most flexible, had a slender body type, weighed less, and demonstrated higher amounts of both functional and absolute strength especially in the upper body. In 1989, Faria et al[41] examined the relationship between anthropometric and physical characteristics of male gymnasts and overall competitive performance success. These researchers concluded that the top gymnasts were stronger in both absolute upper body strength and upper body strength relative to bodyweight, possessed greater overall flexibility through the hip region, shoulder girdle, and back, and possessed the least percentage of body fat.[41] Neither of these studies used a standardized measurement tool to determine an overall fitness score or explore the relationship between age or body weight and physical abilities.

Without a reliable and valid field-test for measuring gymnasts' physical abilities, fitness evaluation and training are often left to the tradition-driven ways of individual coaches. As stated by Sands,[19] "…. Gymnasts often simply 'trick' themselves into shape meaning they perform skills over and over until they acquire the fitness and skill to perform the movement".(p.367) This may lead to an athlete who is simply fit to do certain skills but who does not have the overall fitness level necessary for prolonged participation in the sport. With the consistent increases in the complexity and difficulty of the gymnastics elements being performed during competition,[7]

Table 1. *Individual Items Comprising the GFMT.*

Item	Targeted Area(s) of Fitness Assessment	Units of Measure for Raw Score
The Rope Climb Test	Strength and endurance, as well as trunk control	Seconds*
The Jump Test	Lower extremity power	cm
The Hanging Pikes Test	Abdominal strength, hip flexor strength, and flexibility as well as grip strength	Number of reps
The Shoulder Flexibility Test	Shoulder complex flexion flexibility	cm/arm length
The Agility Test	Speed, endurance, and agility	Seconds
The Over-grip Pull-up Test	Upper extremity strength and muscular endurance	Number of reps
The Splits Test	Pelvis and lower extremity flexibility	Sum of cm split clearance/leg length
The Push-up Test	Shoulder and upper extremity strength	Number of reps
The 20-Yard Sprint Test	Speed and power	Seconds
The Handstand Test	Upper extremity strength and endurance as well as balance in a head-down position	Seconds
* Signifies a form component within the final item score		

a reliable and valid method of measuring and monitoring gymnast's total physical fitness levels is needed to collectively measure the physical abilities of gymnasts and monitor their physical state.

Establishing the reliability and validity of a measurement tool is a multi-step and complex process that must be investigated within the context of the tool's intended use. Various types of validity must be considered when evaluating a new measurement tool. Construct validity, or the ability of a tool to measure the abstract concept it is intended to evaluate, is one type of validity that must be assessed. Methods of construct validation include convergence and discrimination, factor analysis, the known groups method, criterion validation, and hypothesis testing.[42] Methods related to hypothesis testing are based on the ability of a measurement tool to reflect specific assumptions that form the framework underlying the theoretical basis of the construct. Given that a single study cannot definitively verify a theory, construct validation is considered to be an on-going process.

Various forms of reliability such as intra-rater reliability, inter-reliability and test-test reliability must also be considered when evaluating a measurement tool. Test-retest reliability is used to establish that a tool will obtain the same results across repeated administrations of the same test. Intervals between test administrations must be long enough to avoid the impact of factors such as subject fatigue and learning effects but close enough to avoid true changes in the measured variable.

Overview of the GFMT

The Gymnastics Functional Measurement Tool (GFMT) was developed to assess a gymnast's overall fitness level while minimizing the impact of gymnastic skill on testing scores.[43,44] Identifying fitness deficits to be targeted for improvement as part of a gymnast's individual training regime may prove useful in injury prevention. As a field-test for female competitive gymnasts of all ages, the GFMT was designed to be carried out by coaches, trainers and therapists using equipment commonly found in any gymnastics gym (club, high school, collegiate, etc.).

Given that successful participation in women's competitive gymnastics requires a combination of abilities related to flexibility, speed, power, strength, muscular endurance, and balance,[1-16] the individual items of the GFMT were developed based on knowledge of these requirements, a review of the literature, and consultation with experts in the field of women's gymnastics.[43,44] The 10 items comprised in the GFMT are summarized in Table 1 and detailed in Appendix I.

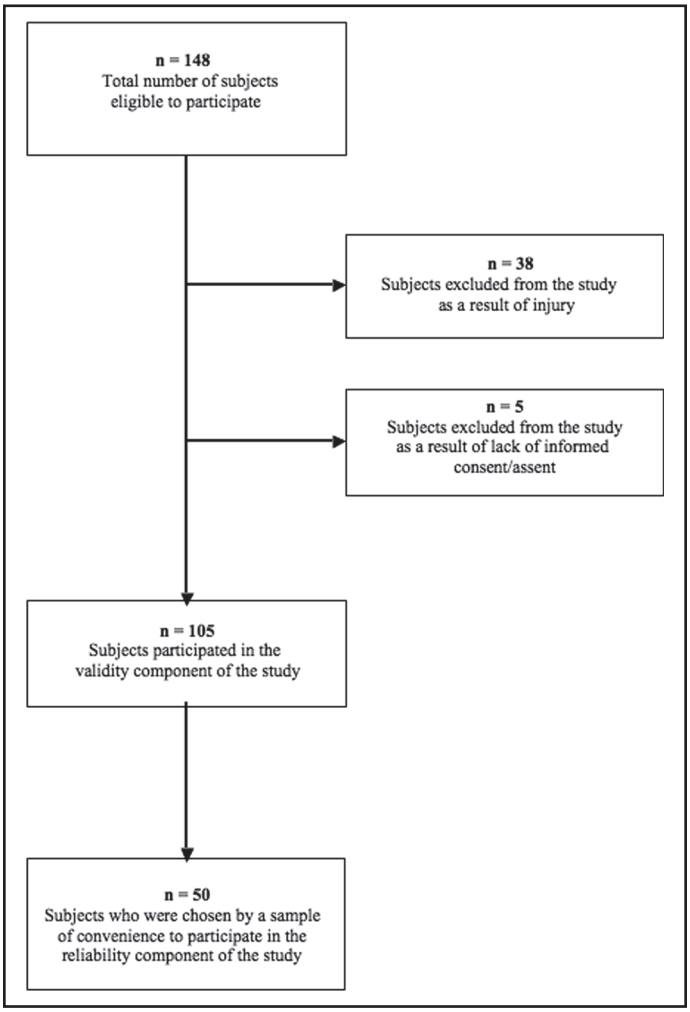


Figure 1. *Flowchart reflecting subject's participation in study.*

The purpose of this study was to continue developing the GFMT by establishing a scoring system for individual test items and initiating the process of establishing test-retest reliability and construct validity. Given the authors' belief that a gymnast's total GFMT score would vary based on her current USAG competitive level, construct validity was assessed using the known-groups method of construct validation.

METHODS

Approval for the study was obtained from the Office for the Protection of Research Subjects at Northwestern University. Healthy competitive female gymnasts were recruited from gymnastics clubs throughout the Midwestern and Mid-Atlantic United States. Inclusion criteria required the subjects to be female, between 6 and 18 years of age, and competitive in gymnastics at USAG levels 4 to 10. Exclusion criteria included musculoskeletal pathology currently limiting the gymnast's ability to train or compete; a history of, or current systemic illnesses including cardiovascular or pulmonary disease; musculoskeletal disease or rheumatoid arthritis; and a lack of informed assent given by the participant or consent given by the parent/legal guardian. A total of 105 subjects participated in the study. Refer to Figure 1 for a flowchart reflecting subjects' participation in the study.

All testing was performed in the subjects' home gyms or in a gym familiar to the subject. Subjects did not have prior knowledge or exposure to the specific items composing the GFMT. Each subject provided her own USAG competition level which was recorded by the testers. Prior to testing, subjects completed their regular, coach-directed warm-up routines without regard to the requirements of the GFMT. Given that field-tests composed of multiple items are often administered in stations each consisting of an individual item,[43,44] subjects were placed into groups of 10 to 12 and moved through each of the 10 stations to complete the GFMT. Data was collected by second year Doctor of Physical Therapy students from Northwestern University and by gymnastics coaches with a minimum of 5 years of coaching experience. In an effort to simulate actual practice patterns,[45-47] all data collectors were provided with a detailed set of instructions for administering each item on the GFMT but did not undergo any specialized or extensive training. Raw data for each item of the GFMT was recorded in units of measurement that were appropriate for the item tested. Units of measurement for the raw data of each item are listed in Table 1. Subjects were not intentionally masked as to their item scores. Individual GFMT items were completed in the following order to help reduce the effects of regional fatigue: Rope Climb Test, Jump Test, Hanging Pikes Test, Shoulder Flexibility Test, Agility Test, Over-grip Pull-up Test, Splits Test, Push-up Test, 20-yard Sprint Test and Handstand Hold Test. Subjects were given a minimum of 5 to 10 minutes rest between administrations of each item of the GFMT.

From the 105 total subjects, a convenience sample of 50 subjects was chosen to participate in test-retest reliability testing. These 50 subjects were retested with the GFMT one week after initial testing. Test conditions and administration were consistent between the 2 administrations of the GFMT including warm-up and item order. To help ensure that test-retest reliability

rather than intra-rater reliability was assessed, testers administered different items from the GFMT on each of the 2 administration dates.

STATISTICAL METHODS

Development of the Scoring System

To develop the scoring system for the GFMT, raw scores in the appropriate units of measurement were recorded for each of the individual items on the GFMT. The raw scores for each item were used to calculate the range, mean, and standard deviation for each individual item of the GFMT (n = 105). Data was then transformed to an ordinal scale using the following procedure. In an attempt to reduce the possibility of ceiling and floor effects, 5 percent of the total range of the raw scores was added to the high score of each item and 5 percent was subtracted from the low score of each item. The resulting range of scores for each individual item was then divided by 11 to create a 0 to 10 ordinal scale for each individual item on the GFMT.[48-50] The ordinal scale for each item was used to create a total GFMT score out of a possible 100 points (10 points for each item). Based on these findings, the scoring for each individual item and for the total GFMT score were finalized and are provided in the GFMT Score Sheet found in Appendix II.

Test-retest and Construct Validity:

Test-retest reliability was analyzed using Model 1 Intraclass correlation coefficients (ICC).[34] Although a process of systematic randomization was not employed in the study, a Model 1 ICC was used to reflect the concept that individual items on the GFMT were administered by different testers on each of the 2 test dates.[42] The variance assessed was thus restricted to differences in the subjects' scores in the test-retest design and necessitated the use of a Model 1 ICC.[42]

Given that previous studies had reported a positive relationship between various singular fitness traits and a gymnast's level of competition,[2,51,52] it was theorized that the total scores on the GFMT would vary with a gymnast's current competitive level. This was based upon the concept that at each increasing competitive level, a gymnast is required to perform increasingly difficult skills that require a related increase in the gymnast's physical abilities. Construct validity was thus evaluated based on the authors' belief that there would be a direct linear relationship between a gymnast's physical abilities as measured by the GFMT and the gymnast's current level of competition as reflected by the gymnast's USAG level. A simple regression analysis was performed using USAG competitive level to predict total GFMT score.[42] The coefficient of determination (r^2) was used to explore this relationship.[42] Statistical significance was set at the $p < 0.05$ level.

RESULTS

Of the 148 subjects assessed for eligibility in this study, 105 subjects participated. Forty-three of the recruited subjects were excluded from the study due to recent injury (n = 38) or the lack of a signed informed consent or assent (n = 5). The mean age of participating subjects was 12.64 years with these subjects reporting participation in competitive gymnastics for a mean of 5.4 years. Mean height and weight of the subjects were 42.76 kg and 149 cm respectively. Subject demographics, categorized by USAG competition level, are summarized in Table 2. Mean GFMT component test raw scores and standard deviations are presented in Table 3.

Raw scores for all items on the GFMT demonstrated a normal distribution with the exception of the Handstand Test, which presented with a right skew. This skew possibly reflects the complexity of this particular activity. The relationships between the subjects' current USAG competitive level and individual component raw scores are presented in Table 4. As indicated in Table 4, several of these relationships were statistically significant, however, r^2 values demonstrated moderate to poor relationships between USAG competitive level and individual component raw scores (r^2 = 0.05-0.47). The relationship between total GFMT scores (out of a possible score of 100) and the subjects' current USAG competitive level was found to be good (r^2 = 0.62). Figure 2 demonstrates the relationship between USAG competitive level and total GFMT Scores. To rule out alternative explanations for the relationship between USAG competitive level and total GFMT scores, the relationships between total GFMT scores and age and total GFMT scores and bodyweight were also explored. Statistically significant relationships were identified between total GFMT score and age and between total GFMT score and bodyweight (r^2 = 0.13). However, r^2 values demonstrated a poor relationship between total GFMT score and age (r^2 = 0.29) and between total GFMT score and bodyweight (r^2 = 0.13).

Table 2. *Subject Demographics by Competitive Level.*

Competition Level	4	5	6	7	8	9	10
Number of Subjects	12	9	16	21	11	19	17
Mean Age in Years (sd)	10.4 (2.3)	9.9 (1.5)	10.7 (1.1)	12.0 (1.6)	13.7 (1.8)	14.6 (1.3)	15.2 (1.8)
Mean Years Competing	2.6	1.8	4.3	4.1	6.4	7.6	8.2
Mean Height in cm (sd)	140 (11.0)	137 (8.4)	139 (6.9)	146 (10.9)	154(3.4)	157 (5.7)	154 (6.2)
Mean Weight in kg (sd)	33.3 (9.1)	32.3 (4.7)	33.8 (3.9)	39.8 (8.2)	46.2 (9.8)	49.0 (5.8)	50.7 (10.7)

sd= Standard Deviation, cm = Centimeters, kg = Kilograms

Table 3. *Mean and Standard Deviation of GFMT Individual Item Scores and GFMT Total Scores (n = 105).*

	Rope Climb Time (secs) Mean (sd)	Vertical Jump Height (cm) Mean (sd)	Hanging Pikes (reps) Mean (sd)	Shoulder Flexibility (cm/arm length) Mean (sd)	Agility (secs) Mean (sd)	Pull-ups (reps) Mean (sd)	Splits (combined [cm/leg length]) Mean (sd)	Push-ups (reps) Mean (sd)	20 Yard Sprint (secs) Mean (sd)	Handstand (secs) Mean (sd)	Total GFMT Score (/100) Mean (sd)
Total sample (Levels 4 -10)	12.40 (6.9)	41.70 (7.2)	17.62 (10.6)	0.773 (0.208)	19.12 (1.3)	8.08 (4.0)	-0.101 (0.382)	24.52 (9.2)	3.29 (0.3)	23.48 (29.5)	50.38 (15.9)
Level 4 scores	16.64 (6.8)	33.33 (4.9)	11.08 (6.9)	0.67 (0.15)	20.73 (0.9)	5.25 (3.4)	-0.38 (0.27)	18.42 (5.6)	3.74 (0.3)	3.67 (5.6)	30.83 (8.5)
Level 5 scores	16.91 (3.8)	31.50 (5.7)	7.67 (9.5)	0.63 (0.13)	20.89 (1.6)	5.11 (4.9)	-0.15 (0.48)	13.22 (7.0)	3.55 (0.3)	3.69 (2.6)	29.78 (12.0)
Level 6 scores	16.35 (5.3)	40.69 (6.6)	17.69 (8.3)	0.80 (0.18)	19.29 (0.7)	8.63 (3.7)	-0.10 (0.35)	26.38 (7.6)	3.37 (0.2)	11.72 (14.6)	48.75 (8.3)
Level 7 scores	15.35 (10.0)	42.74 (5.2)	13.14 (9.4)	0.85 (0.23)	19.23 (0.9)	7.52 (4.1)	-0.15 (0.45)	22.95 (9.4)	3.28 (0.2)	11.31 (19.2)	46.71 (10.2)
Level 8 scores	12.15 (3.2)	44.45 (5.1)	15.73 (8.6)	0.80 (0.28)	18.66 (1.2)	7.00 (2.8)	-0.05 (0.27)	22.45 (8.0)	3.21 (0.2)	15.38 (17.8)	50.91 (10.5)
Level 9 scores	11.97 (3.0)	44.42 (3.2)	24.11 (8.0)	0.70 (0.12)	18.24 (0.8)	8.26 (2.4)	-0.02 (0.38)	27.42 (6.9)	3.09 (0.2)	42.38 (31.7)	59.00 (7.9)
Level 10 scores	11.10 (1.7)	47.82 (6.2)	26.94 (10.0)	0.87 (0.23)	18.04 (0.7)	12.29 (2.9)	0.06 (0.33)	33.12 (6.5)	3.01 (0.2)	58.18 (32.3)	71.18 (9.4)

Sd= Standard Deviation, cm = Centimeters, kg = Kilograms, secs = Seconds, deg = Degrees, reps = Repetitions.

Raw item scores were used to examine the test-retest reliability for each item on the GFMT. Test-retest reliability of total GFMT scores was also determined. Reliability testing of the GFMT total score showed good test-retest reliability over a one week period (ICC = 0.97). Test-retest reliability of the individual component tests was good to excellent (ICC = 0.80-0.92).[42] Reliability coefficients are shown in Table 5. A statistically significant difference ($p < 0.05$) between the first and second test scores was identified for the GFMT Total score and for the following test items: the Hanging Pikes Test, the Vertical Jump Test, and the Splits Test.

Table 4. *Relationship between GFMT Individual Test Raw Score and Composite Score and the Subjects' Current Competitive Level, Body Weight and Age (n = 105).*

	Rope Climb Component Score	Vertical Jump Height (cm)	Hanging Pikes (reps)	Shoulder Flexibility (cm/arm length)	Agility (secs)	Pull-ups (reps)	Splits (combined [cm/leg length])	Push-ups (reps)	20 Yard Sprint (secs)	Handstand (secs)	Total Score (/100)
Test score vs. Competitive Level	0.27	*0.42	*0.27	*0.05	*0.47	*0.20	*0.09	*0.25	*0.47	*0.38	*0.62
Test score vs. Age	*0.14	*0.28	*0.06	0.00	*0.38	*0.04	0.01	*0.10	*0.42	*0.18	*0.29
Test score vs. Body weight (kg)	*0.10	*0.26	0.01	0.00	*0.31	0.00	0.00	0.03	*0.32	0.02	*0.13

Values expressed in terms of Coefficient of Determination (r^2)
* Denotes statistical Significance ($p<.05$)

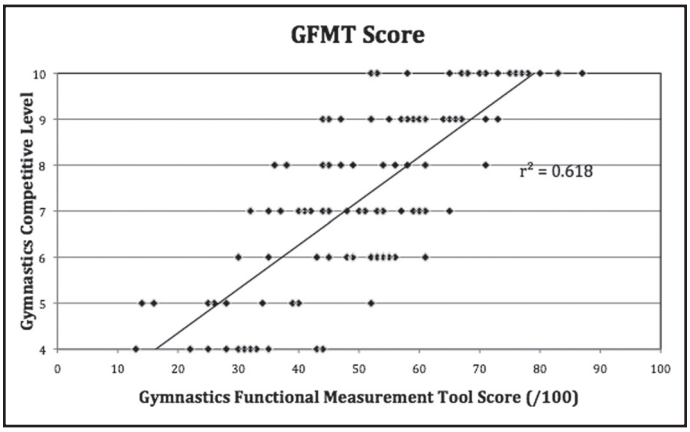


Figure 2. *Relationship between USAG score and GFMT score.*

DISCUSSION

The GFMT provides the coaches, trainers, and therapists who work with female gymnasts of any age or competitive level with a functional tool designed to assess the unique aspects of fitness that are necessary for safe and effective participation in the sport. Given that the GFMT was developed as a field-test that can be administered without extensive training using equipment readily available in a gymnastics gym, the authors believe that the GFMT can be easily incorporated into any gymnastics program. Identifying fitness deficits that can be targeted as part of a gymnast's individual training regime may prove useful in injury prevention.

Table 5. *Score Means and Standard Deviations for Both Test Days and Intraclass Correlation Coefficients for Test Retest Reliability (n = 50).*

	Rope Climb Time (secs) Mean (sd)	Vertical Jump Height (cm) Mean (sd)	Hanging Pikes (reps) Mean (sd)	Shoulder Flexibility (cm/arm length) Mean (sd)	Agility (secs) Mean (sd)	Pull-ups (reps) Mean (sd)	Splits (combined [cm/leg length]) Mean (sd)	Push-ups (reps) Mean (sd)	20 Yard Sprint (secs) Mean (sd)	Handstand (secs) Mean (sd)	Total GFMT Score (/100) Mean (sd)
Test Day 1 scores	5.86 (1.9)	40.47 (6.8)	16.84 (8.3)	0.77 (0.2)	19.54 (1.3)	8.32 (4.2)	-0.008 (0.40)	25.2 (9.9)	3.81 (0.2)	21.46 (29.3)	48.54 (15.0)
Test Day 2 scores	6.61 (2.0)	41.93* (7.1)	19.84* (9.9)	0.79 (0.2)	19.51 (1.2)	8.58 (3.4)	-0.092* (0.36)	26.42 (10.3)	3.82 (0.3)	24.70 (32.5)	51.26* (15.5)
Test re-test reliability ICC	0.80	0.83	0.88	0.92	0.86	0.89	0.91	0.84	0.85	0.92	0.97

* Signifies statistically significant difference from Test Day 1 scores $p<0.05$

Raw data collected in this study was used to develop the scoring system for the GFMT. Transformation of the raw data for each individual item to an ordinal scale allowed for a total GFMT score out of a possible 100 points (10 points for each item) and permitted raw data based on a variety of units of measurement to be considered within a total score. As reflected in Appendix I, the raw score for the Rope Climb item reflects both the amount of time needed to complete the climb and the qualitative analysis of the climbing technique used by the gymnast during the climb. Scoring for this item thus reflects a 0 to 5 ordinal scale for time developed using the procedures outlined above as well as a 0 to 5 score for climbing technique as outlined in Appendix I.

The results of this study provide initial support for the construct validity and test-retest reliability of the GFMT. Although construct validity is only one of the many forms of validity to be considered when evaluating a measurement tool,[42,46] the relationship between a gymnast's total GFMT score and current USAG competitive level provides support for the concept that GFMT scores will vary based on a gymnast's current competitive level. Examining data from the individual items comprising the GFMT reveals that certain items such as the Jump Test, the Agility Test, and the 20-Yard Sprint Test relate more strongly to a gymnast's current competitive level than items such as the Shoulder Flexibility Test and the Splits Test. Despite the variations in the strength of the relationship between individual items and competitive level, the authors believe that all items on the GFMT must be administered to fully assess a gymnast's fitness across multiple domain areas (strength, flexibility, power, etc.). Maintaining a complete representation of fitness within the GFMT is necessary in order to adequately identify a gymnast's fitness deficits and aid in the development of a fitness program tailored to address individual fitness needs.

The procedures and methods used in this study allowed the researchers to evaluate the GFMT within the context of its intended use as a field-test to assess a gymnast's overall fitness level while minimizing the impact of gymnastic skill on testing scores.[43,44] As such, testing was conducted in a manner consistent with the sport in an environment familiar to the individual athletes. Each item on the GFMT was administered at a separate station by different testers to reflect the common practices of field-test administration. Testers were intentionally provided with detailed instructions for administering each item but did not undergo extensive or additional training. Results are therefore felt to reflect the application of the GFMT within the setting for which it was intended to be used.

The intended purpose and use of a measurement tool dictate the relative importance of various forms of reliability. Given that the GFMT was designed as a physical fitness field-test, assessment of test-retest reliability was felt to be essential. The one week interval between test administrations attempted to control for factors such as fatigue or learning effects that may have impacted a gymnast's performance while trying to avoid enough passage of time to permit a true change in a gymnast's overall fitness.

This study was limited by several factors. The total number of participants at any given USAG level ranged from 9 to 21. Increasing these numbers to ≥30 participants at each USAG level may have yielded different results. Although methods such as using physical therapy students and coaches to collect the data may have helped to reflect the use of the GFMT within the context of its intended use, greater methodological control and therefore different results may have been obtained through the use of more stringent techniques such as employing highly trained, researching physical therapists to collect the data. While attempts were made in the test-retest procedures to decrease the possibility of a practice or learning effect, the authors' recognize that such factors may have impacted score differences between the first and second administrations of the GFMT.

Further research is needed to continue the process of establishing the various types of reliability and validity of the GFMT. The possibility of correlations between total GFMT score and such factors as body composition/percentage of body fat and body mass index must be explored. Future studies should also explore the ability of the GFMT total score and individual item scores to identify a gymnast's risk for specific injuries and whether the GFMT could be used to help determine if and when an injured gymnast can safely resume high-level training and competition. Finally, since the GFMT was developed exclusively for female gymnasts, a different tool that reflects the demands and specifications of men's competitive gymnastics should also be developed.

CONCLUSION

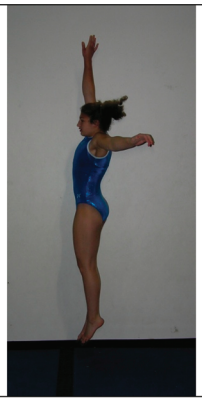
Although the process of establishing the reliability and validity of any measurement tool is a complex and lengthy procedure, the results of this study provide initial support for the construct validity and test-retest reliability of the GFMT.

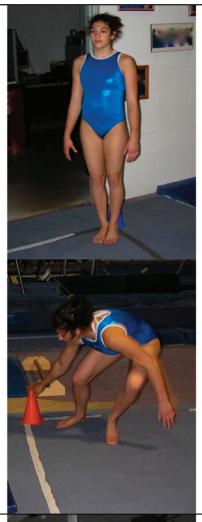
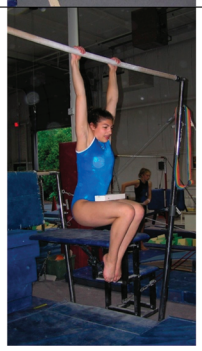
REFERENCES

1. Bradshaw E. Target-directed running in gymnastics: a preliminary exploration of vaulting. *Sports Biomech.* Jan 2004;3(1):125-144.
2. Lindner KJ, Caine DJ, Johns DP. Withdrawal predictors among physical and performance characteristics of female competitive gymnasts. *J Sports Sci.* Autumn 1991;9(3):259-272.
3. Nelson JK, Johnson BL, Smith GC. Physical characteristics, hip flexibility and arm strength of female gymnasts classified by intensity of training across age. *J Sports Med Phys Fitness.* Mar 1983;23(1):95-101.
4. Sands W, McNeal J, Borms J, Jemni M. Sprint characteristics of talent-selected female gymnasts age 9-11 years. *International Science in Gymnastics Symposium.* Vol Annaheim, CA: USA-Gymnastics; 2003.
5. Bradshaw EJ, Le Rossignol P. Anthropometric and biomechanical field measures of floor and vault ability in 8 to 14 year old talent-selected gymnasts. *Sports Biomech.* Jul 2004;3(2):249-262.
6. Sands W, Caine D, Borms J. Scientific Aspects of Women's Gymnastics. *Medicine and Sports Science.* 2003;45.
7. Daly RM, Bass SL, Finch CF. Balancing the risk of injury to gymnasts: how effective are the counter measures? *Br J Sports Med.* Feb 2001;35(1):8-18; quiz 19.
8. Delas S, Babin J, Katic R. Effects of biomotor structures on performance of competitive gymnastics elements in elementary school female sixth-graders. *Coll Antropol.* Dec 2007;31(4):979-985.
9. Kirby RL, Simms FC, Symington VJ, Garner JB. Flexibility and musculoskeletal symptomatology in female gymnasts and age-matched controls. *Am J Sports Med.* May-Jun 1981;9(3):160-164.
10. Knapik JJ, Bauman CL, Jones BH, Harris JM, Vaughan L. Preseason strength and flexibility imbalances associated with athletic injuries in female collegiate athletes. *Am J Sports Med.* Jan-Feb 1991;19(1):76-81.
11. Knapik JJ, Jones BH, Bauman CL, Harris JM. Strength, flexibility and athletic injuries. *Sports Med.* Nov 1992;14(5):277-288.
12. Maffulli N, King JB, Helms P. Training in elite young athletes (the Training of Young Athletes (TOYA) Study): injuries, flexibility and isometric strength. *Br J Sports Med.* Jun 1994;28(2):123-136.
13. Peltenburg AL, Erich WB, Bernink MJ, Huisveld IA. Selection of talented female gymnasts, aged 8 to 11, on the basis of motor abilities with special reference to balance: a retrospective study. *Int J Sports Med.* Feb 1982;3(1):37-42.
14. Bencke J, Damsgaard R, Saekmose A, Jorgensen P, Jorgensen K, Klausen K. Anaerobic power and muscle strength characteristics of 11 years old elite and non-elite boys and girls from gymnastics, team handball, tennis and swimming. *Scand J Med Sci Sports.* Jun 2002;12(3):171-178.
15. Delas S, Zagorac N, Katic R. Effects of biomotor structures on performance of competitive gymnastics elements in elementary school male sixth-graders. *Coll Antropol.* Jun 2008;32(2):443-449.
16. Jemni M, Sands WA, Friemel F, Stone MH, Cooke CB. Any effect of gymnastics training on upper-body and lower-body aerobic and power components in national and international male gymnasts? *J Strength Cond Res.* Nov 2006;20(4):899-907.
17. Fellander-Tsai L, Wredmark T. Injury incidence and cause in elite gymnasts. *Arch Orthop Trauma Surg.* 1995;114(6):344-346.
18. Lindner K, Caine D. Injury predictors among female gymnasts' anthropometric and performance characteristics. In: Hermans G, Mosterd W, eds. *Sports, Medicine and Health*. Amsterdam: Excerpta Medica; 1990:136–141.
19. Sands WA. Injury prevention in women's gymnastics. *Sports Med.* Nov 2000;30(5):359-373.
20. Nimmerichter A, Williams C, Bachl N, Eston R. Evaluation of a field test to assess performance in elite cyclists. *Int J Sports Med.* Mar 2010;31(3):160-166.
21. Chamari K, Chaouachi A, Hambli M, Kaouech F, Wisloff U, Castagna C. The five-jump test for distance as a field test to assess lower limb explosive power in soccer players. *J Strength Cond Res.* May 2008;22(3):944-950.
22. Gonzalez-Haro C, Galilea PA, Drobnic F, Escanero JF. Validation of a field test to determine the maximal aerobic power in triathletes and endurance cyclists. *Br J Sports Med.* Mar 2007;41(3):174-179.
23. Girard O, Chevalier R, Leveque F, Micallef JP, Millet GP. Specific incremental field test for aerobic fitness in tennis. *Br J Sports Med.* Sep 2006;40(9):791-796.
24. Wonisch M, Hofmann P, Schwaberger G, von Duvillard SP, Klein W. Validation of a field test for the non-invasive determination of badminton specific aerobic performance. *Br J Sports Med.* Apr 2003;37(2):115-118.
25. Dabonneville M, Berthon P, Vaslin P, Fellmann N. The 5 min running field test: test and retest reliability on trained men and women. *Eur J Appl Physiol.* Jan 2003;88(4-5):353-360.

26. Wragg CB, Maxwell NS, Doust JH. Evaluation of the reliability and validity of a soccer-specific field test of repeated sprint ability. *Eur J Appl Physiol.* Sep 2000;83(1):77-83.
27. Vanlandewijck YC, Daly DJ, Theisen DM. Field test evaluation of aerobic, anaerobic, and wheelchair basketball skill performances. *Int J Sports Med.* Nov 1999;20(8):548-554.
28. Laconi P, Melis F, Crisafulli A, Sollai R, Lai C, Concu A. Field test for mechanical efficiency evaluation in matching volleyball players. *Int J Sports Med.* Jan 1998;19(1):52-55.
29. Labsy Z, Collomp K, Frey A, De Ceaurriz J. Assessment of maximal aerobic velocity in soccer players by means of an adapted Probst field test. *J Sports Med Phys Fitness.* Dec 2004;44(4):375-382.
30. Nicholas CW, Nuttall FE, Williams C. The Loughborough Intermittent Shuttle Test: a field test that simulates the activity pattern of soccer. *J Sports Sci.* Feb 2000;18(2):97-104.
31. Gauffin H, Pettersson G, Tegner Y, Troop H. Function testing in patients with old rupture of the anterior cruciate ligament. *Int J Sports Med.* 1990;11(1):73-77.
32. Pauole K, Madole K, Garhammer J, Lacourse M, Rozenek R. Reliability and validity of the T-test as a measure of agility, leg power, and leg speed in college-aged men and women *J Strength Condition Res.* 2000;14(4):443-450.
33. Cook G, Burton L, Hoogenboom B. Pre-participation screening: the use of fundamental movements as an assessment of function - Part 1 *North Am J Sports Phys Ther.* 2006;1(2):62-72.
34. Cook G, Burton L, Hoogenboom B. Pre-participation screening: the use of fundamental movements as an assessment of function - Part 2 *North Am J Sports Phys Ther.* 2006;1(3):132-139.
35. Bajin B. Talent Identification Program for Canadian Female Gymnasts. In: Petiot B, Salmela JH, Hoshizaki TB, eds. *World Indentification Systems for Gymnastic Talent*. Montreal: Sports Psyche Editions; 1987.
36. Ho R. Talent Identification in China. In: Petiot B, Salmela JH, Hoshizaki TB, eds. *World Identification Systems for Gymnastic Talent*. Montreal: Sports Psyche Editions; 1987.
37. Sands W. Physical Abilities Profile - 1993 National TOPs testing. *Technique.* Vol 14. 1994:15-20.
38. Sands WA. Olympic Preparation Camps 2000 - Physical Ability Testing. *Technique.* 2000;20(10):6-19.
39. USA-Gymnastics. Official National Tops Testing Website. 2005; Forth:http://www.usa-gymnastics.org/women/pages/elite_preelite_tops.php. Accessed March 5, 2010.
40. Sawczyn S, Zasada M. The Aerobic and Anaerobic Power of the Best Young Gymnasts - Indication of Training Endurance Capabilities. *Research Yearbook.* 2007;13(1):86-89.
41. Faria IE, Faria EW. Relationship of the anthropometric and physical characteristics of male junior gymnasts to performance. *J Sports Med Phys Fitness.* Dec 1989;29(4):369-378.
42. Portney L, Watkins M. *Foundations of Clinical Research: Applications to Practice*. third ed. Upper Saddle River, NJ: Pearson/Prentice Hall; 2009.
43. Sleeper M, Beers M, Erwin M, et al. The Gymnastics Functional Measurement Tool: An Instrument for the Physical Assessment of Competitive Gymnasts. Paper presented at: American College of Sports Medicine2006; Denver, CO.
44. Sleeper M, Casey E. The Gymnastics Functional Measurement Tool: A Valid way of Measuring Gymnastics Physical Abilities. Paper presented at: American Physical Therapy Association Combined Sections Meeting2010; San Diego, CA.
45. Blackburn M, van Vliet P, Mockett SP. Reliability of measurements obtained with the modified Ashworth scale in the lower extremities of people with stroke. *Phys Ther.* Jan 2002;82(1):25-34.
46. Sechrest L. Validity of measures is no simple matter. *Health Serv Res.* Oct 2005;40(5 Pt 2):1584-1604.
47. Strauss ME, Smith GT. Construct validity: advances in theory and methodology. *Annu Rev Clin Psychol.* 2009;5:1-25.
48. Rothstein J, Campbell S, Echternach J, Jette A, Knecht H, Rose S. Standards for test and measurements in physical therapy practice. *Physical Therapy.* 1991;71(8):589-622.
49. Rothstein J, Echternach J. *Primer on Measurement: An Introductory Guide to Measurement Issues*. 1st ed. Alexandria, VA: American Physical Therapy Association; 1993.
50. Streiner D, Norman G. *Health Measurement Sclaes: A Practical Guide to Their Development and Use*. 3rd ed. Oxford, England: Oxford University Press; 2003.
51. Grabinar MD, McKelvain R. Implementation of a Profiling/Prediction Test Battery in the Screening of Elite Men Gymnasts. In: Petiot B, Salmela JH, Hoshizaki TB, eds. *World Identification Systems for Gymnastic Talent*. Montreal: Sports Psyche Editions; 1987.
52. Regnier G, Salmela HH. Predictors of Success in Canadian Male Gymnasts. In: Petiot B, Salmela JH, Hoshizaki TB, eds. *World Identification Systems for Gymnastic Talent*. Montreal: Sports Psyche Editions; 1987.

APPENDIX 1: INSTRUCTIONS FOR ADMINISTRATION OF THE GFMT.

Item	Procedure	Comments and Illustrations
Rope Climb Test	-The gymnast starts in a seated pike (legs together) position directly beneath a vertical rope with her hands on a "starting line" marked on the rope. -The test and timing begins when the gymnast leaves the floor. The gymnast must attempt to maintain a pike position at a horizontal level throughout the test. -The tester stops timing when the gymnast touches a 15-foot mark measured from the "starting line" or is unable to continue climbing. -Scoring is based on the gymnast's ability to complete the climb, the amount of time to perform the climb, climbing technique (hand to hand or hand over hand) and hip and leg position maintained during the climb. ♦ The pike position must be held to the side of the rope; the gymnast may not straddle the rope. ♦ The rope can be held by an assistant for stability throughout the test if the gymnast requests. -Scoring: ♦ Hand over hand climb – 90 degree hip flexion – 5 points ♦ Hand over hand climb – hips not maintained at 90 degree flexion – 4 points ♦ Hand over hand climb with help of legs – 3 points ♦ Hand to hand climb, with help from legs – 2 points ♦ Unable to complete 15 feet – 1 point ♦ Unable to climb – 0 points	   4 points 3 points
The Jump Test	-Before the Jump Test, the gymnast places a generous amount of chalk on her fingers so that accurate measurements can be made. -The gymnast stands with her dominant side to the wall (but not against it) and perform a vertical jump using both legs, placing a chalk mark on the wall at the top of her jump. -The jump must be performed by pushing off from both lower extremities equally. -Following the jump, standing flat-footed with the dominant side to the wall, the gymnast reaches with the chalked hand directly overhead, touching the wall and leaving a mark of chalk at the highest point. -Using a tape measure, the examiner measures and records the distance between the tops of the two chalk marks in a line perpendicular to the floor to the nearest centimeter.	
The Hanging Pikes Test	-The gymnast begins the test from a dead hang, without the use of handgrips, on a standard horizontal bar. -The gymnast is then asked to flex at the hips with legs together and knees extended and attempt to touch her toes to the bar. -Between pike attempts, the gymnasts must be in a momentary dead hang to prevent the use of momentum to gain an advantage for her next pike-up. -The test score is based on the number of pikes completed.	
The Shoulder Flexibility Test	-Prior to shoulder flexibility testing, the gymnast's arm length is measured from the tip of the acromion process to a ½ inch wooden dowel grasped by both hands while holding her shoulders flexed to 90 degrees. -For testing, the gymnast lies prone on a firm floor with her chin and nose touching the floor. -Both arms are held parallel to the body with the shoulders flexed to 180 degrees. -The gymnast grasps the 1/2-inch dowel with an overhand grip and tips of her thumbs touching. -The gymnast is asked to maximally flex her shoulders while maintaining her wrists in a neutral position, elbows extended and her nose and chin in contact with the floor. -The wooden dowel must be kept parallel to the floor. -Once the gymnast has raised her arms to their maximum height, the distance from the dowel, where her thumbs are touching, to the floor is measured and recorded to the nearest ½ centimeter using a rigid meter stick. -The gymnast must hold this position long enough to record the measurement. -The Shoulder Flexibility Test raw score is calculated by dividing the dowel height attained by the length of the athlete's arm	 

The Agility Test	- Two 6-inch cones are placed diagonally at the corners of a 12m x 12m gymnastics competition floor. - The gymnast starts standing in one corner of the floor in front of the cone with her feet together as if she were preparing for a tumbling pass. - When ready, the gymnast is instructed to sprint across the diagonal length of the floor, decelerate, touch the 6-inch cone and then turn around and repeat the run for a total of five passes ending in the corner opposite from where she started. - Timing starts as soon as the gymnast lifts a foot from the standing position. - Timing is stopped when any part of the gymnast's torso crosses over the finish line, which is an imaginary vertical plane from the corner of the floor. - Time is recorded with a stopwatch to the nearest hundredth of a second.	
The Over-grip Pull-up Test	- The gymnast performs pull-ups starting in a hanging position from the standard horizontal bar with an overhand grip and hips and knees flexed to 90 degrees. Gymnastics grips cannot be used. - A 16-inch length of 1-inch x 4-inch wood is placed on the thighs, at the hip. - The gymnast then completes as many pull-ups as possible while maintaining the starting lower extremity position. - A complete pull-up is defined as starting in a full hanging position (elbows extended) and raising the chin so that it clears the horizontal bar completely. - A pull-up does not count if the chin does not clear the bar, if the gymnast does not start in a fully extended (elbow) position or if the block of wood falls. - The test can continue as long as the grip is maintained and the evaluator replaces the block of wood. - The tester records the total number of completed pull-ups for scoring. - The test will be terminated after 3 unsuccessful attempts or if the gymnast leaves the bar.	
The Splits Tests	- Performance of the Splits Test involves left, right, and middle split measurement. - Left/Right Split: Split testing will be carried out on the left and the right leg following the same procedure. • The left split is done in a position in which the left hip is flexed maximally and the right hip is extended maximally. • Before testing, the length of the gymnast's dominant leg is measured from the anterior superior iliac spine to a point on the anterior surface of the ankle in between the lateral and medial malleolus. • During both left and right splits testing, the gymnast places the anterior aspect of her trailing leg's tibia up against a wall in a vertical position to maintain the hip and pelvis in a neutral position. • She is then instructed to slide her lead foot out into a split position. • Her back must be in a vertical position and hips and shoulders must be square or parallel to the wall. • The gymnast is allowed to use paralettes on the left and right for support and to help maintain the proper test position. • This position ensures the pelvis is in a standardized neutral position. • The measurement is taken between the highest point of clearance in the perineal area and the floor. • One individual can be used to ensure the trailing leg is maintained in a vertical position by holding it in place if needed. • Split measurement is made from the posterior aspect of the gymnast. • A rigid centimeter ruler is held against the gymnast's sacrum to measure the distance between the highest point of clearance in the perineal area and the floor to the nearest centimeter. If the gymnast is unable to perform the split completely to the floor, the measurement is referred to as a negative (-) centimeter measurement. • If the gymnast can achieve full contact during the split, an over-split should be performed. o The over-split involves an assistant passively flexing the lead hip while the gymnast maintains a neutral pelvis and extended knee position. o The hip is flexed until the gymnast says, "stop" or until the pelvis is lifted from the floor. The height from the posterior aspect of the heel to the floor is measured and recorded in cm. o The over-split measurement should be referred to as positive (+) centimeter - Middle split testing involves the use of a straight line on the floor. • The gymnast is instructed to start the test in a standing position with her heels on the line and feet perpendicular to it. • She is then instructed to slide into a middle split position (both hips abducted maximally) keeping her legs parallel to or on the line. • The gymnast must lean forward and place her chest on the ground in order to obtain the lowest split position. • Once the correct testing position has been obtained, a measurement is taken from the point where the inguinal ligament crosses the leotard line and the floor. • If a gymnast is in full contact with the floor during correct performance of the middle split, an over split may be carried out and measured in the same manner described for the left and right splits. • The gymnast's dominant lower extremity will be used for over-split measurements. • The positive or negative angles calculated from the left, right and middle are then added to give a final split score. - The Splits Test raw score will be determined by dividing left, right and middle split perineal height (negative value) or the heel height in the case of an oversplit (positive value) measurement by the leg length and adding the values.	 

The Push-up Test	- The gymnast starts with her hands shoulder width apart on a low beam. - The gymnast's thumbs are placed directly under the shoulders and the elbows positioned away from her side. - The gymnast's feet are to be placed together on a panel mat of the same height as the beam. - The push-up is then performed with the body in a straight, horizontal position. - The gymnast will lower herself until she touches a 1-inch high block placed directly under her chest. - Following the chest-to-block contact, the gymnast must extend the elbows until they are locked. - The slowest cadence allowed for the push-up is 1 second up and 1 second down. - The gymnast should perform as many push-ups as possible. Push-ups do not count if the gymnast fails to reach the block of wood or if she does not fully extend her elbows; however, the test can still proceed. - The test score is based on the total number of properly completed push-ups.	   Incorrect terminal arm position
The 20-Yard Sprint Test	- The sprint test should be performed on a vault runway. Sufficient space must be given past the finish line to ensure that the gymnast is able to slow down. - The gymnast begins standing with her feet together. - The time begins as soon as the gymnast's left or right foot leaves the floor and is stopped when any part of the gymnast's torso crosses the finish line. - Time is recorded with a stopwatch to the nearest hundredth of a second. One trial is allowed.	

The Handstand Test	- The gymnast starts the handstand with hands at a comfortable distance apart on a low beam. - A handstand position, which is defined as any position in which the gymnast's total bodyweight is supported entirely by the hands, can be accomplished any way the gymnast wishes. - Timing begins when the gymnast's feet leave the ground, and timing stops when any part of the gymnast's body (other than the hands) touches the beam or the floor or if either of her hands moves from their original position. - Time is recorded with a stopwatch to the nearest tenth of a second. - The participant is given two trials for this test and her longest time will be used for scoring.	

Gymnastics Functional Measurement Tool (GFMT)

Score Sheet

Subject ID _____ **Level**_____ **Date** _____

***Any physical symptoms must be reported to the coach or test administrator and be documented**

1. **Rope Climb**:Testing Muscular strength and endurance **TEST SCORE /10**_____
   a. Form
      i. Hand over hand climb – 90 degree hip flexion 5 pts
      ii. Hand over hand climb – hips not maintained at 90 degree flexion 4 pts
      iii. Hand over hand climb with help of legs 3 pts
      iv. Hand to hand climb, with help from legs 2 pts
      v. Unable to complete 1 pts
      vi. Unable to climb 0 pts
   b. Time _____
      i. 0-10 seconds = 5 points, 10.1-12 seconds = 4 points, 12.1 -14 seconds = 3 points, 14.1-16 seconds = 2 points, 16.1 seconds – 18 seconds = 1 point, > 18 seconds = 0 points

      Symptoms and comments*

      _____

2. **Jump Test:** Testing power **TEST SCORE /10** _____
   a. Difference in the distance between static stand and reach height and maximal height achieved with a vertical counter movement jump.
      i. Jump height in cm _____
         1. (<. 26.5cm=0 pts, 26.5-30.9cm=1 pts, 31-34.4cm=2 pts, 34.5-37.9cm=3 pts, 38-41.4cm=4 pts, 41.5-44.9cm=5 pts, 45-48.4cm=6 pts, 48.5-51.9cm=7 pts, 52-55.4cm=8 pts, 55.5-58.9cm=9 pts, >59cm=10 pts)

      Symptoms and comments*

      _____

3. **Hanging Pikes:** Testing Muscular strength and endurance **TEST SCORE /10** ____
   a. Number of pikes achieved to touch the bar
      i. Number of completed Pikes _____
         1. 1-10 Score: (0 = 0 pts, 1-4=1, 5-8=2, 9-12=3, 13-16=4, 17-20 =5, 21-24 = 6, 25-28=7, 29-32=8, 33-36 = 9, >36 =10)

      Symptoms and comments*

      _____

4. **Shoulder Flexibility:** Testing Flexibility **TEST SCORE /10** _____
   a. Arm length (Acromion process to wooden rod) _____cm
   b. Distance From Floor _____cm
      i. 0-10 Score: (distance from floor/arm length)
         1. (<.349 = 0pts, 0.35-0.46 = 1 pts, 0.461-0.57 = 2 pts, 0.571-0.68 = 3 pts, 0/681-0.79 = 4 pts, 0.791-0.90 = 5 pts, 0.91-1.01= 6 pts, 1.011-1.12 = 7 pts, 1.121-1.23 = 8 pts, 1.231-1.25=9 pts, >1.25=10 pts)

      Symptoms and comments*

      _____

5. **Agility Sprint:** Testing Speed, endurance and agility **TEST SCORE /10** _____
   a. Time _____
      i. 0-10 Score:
         1. (>22 seconds = 0 pts, 22-21.5 seconds =1 pts, 21.51-21.0 seconds = 2 pts, 21.01-20.5 seconds = 3 pts, 20.51-20 seconds =4 pts, 20.01-19.5 seconds =5 pts, 19.51-19.0 seconds =6 pts, 19.01-18.5 seconds =7 pts, 18.51-18.01 seconds =8 pts, 18-17.5 seconds =9 pts, <17.5 seconds =10 pts)

      Symptoms and comments*

      _____

6. **Over-grip Pull-ups:** Testing Muscular strength and endurance **TEST SCORE /10 _____**
    a. Number of completed Chin-ups _____
        i. 0-10 Score:
            1. (0=0 pts, 1-2=1 pts, 3-4=2 pts, 5-6=3 pts, 7-8=4 pts, 9-10=5 pts, 11-12=6 pts, 13-14=7 pts, 15-16=8 pts, 17-18=9 pts, >18=10 pts)

    Symptoms and comments*

    _____

7. **Split Test: L, R, and Middle**: Testing Flexibility **TEST SCORE /10 _____**
    a. Score will be combination of Distances from the floor for all three splits ("-"=standard split, "+" = over-split)
        i. Leg Length (cm) L_____ R_____
            1. L split (-) _____cm Over split (+) _____cm Raw cm/leglength ____
            2. R split (-) _____cm Over split (+) _____cm Raw cm/leglength ____
            3. Middle split (-)_____cm Over split (+) _____cm Raw cm/leglength ____
        ii. 0-10 Score: (Sum of all 3 raw scores) <-0.90 = 0 pts, (-)0.899-(-)0.700 = 1 pts, ,(-)0.699-(-) 0.500 =2 pts, (-)0.499-(-)0.300 = 3 pts, (-)0.299-(-)0.100 = 4, (-)0.099-1.0 = 5 pts, (+)1.01-(+)3.00 = 6 pts, (+)3.01-(+)5.00 = 7 pts, (+)5.01-(+)7.00 = 8 pts, (+)7.01-9.00 = 9 pts, > (+)9.01 = 10 pts

    Symptoms and comments*

    _____

8. **Push-up Test:** Testing Muscular strength and endurance **TEST SCORE /10 _____**
    a. Number of completed Push-ups _____
        i. 0-10 Score: (0=0 pts, 1-5=1 pts, 6=10=2 pts, 11=15=3 pts, 16-20=4 pts, 21-25=5 pts, 26-30=6 pts, 31-35=7 pts, 36-40=8 pts, 41-45=9 pts, 45 > =10 pts)

    Symptoms and comments*

    _____

9. **20 Yard Sprint:** Testing Speed **TEST SCORE /10 _____**
    a. Time _____
        i. 0-10 Score: >4.3 seconds= 0, 4.29-4.14= 1 pts, 4.13-3.98=2 pts, 3.97-3.83= 3 pts, 3.82-3.67= 4 pts, 3.66-3.52= 5 pts, 3.51-3.36= 6 pts, 3.35-3.21= 7 pts, 3.20-3.05= 8 pts, 3.04-2.91= 9 pts, <2.90=10 pts)

    Symptoms and comments*

    _____

10. **Handstand Hold:** Testing Muscular endurance and balance **TEST SCORE /10 _____**
    a. Best time with 2 attempts
        i. Time held trial #1 _____ Time held trial #2 _____
            1. 0-10 Score: (0=0 pts, 1-7 seconds =1 pts, 8-15=2 pts, 16-23=3 pts, 24-31=4 pts, 32-39=5 pts, 40-47=6 pts, 48-55=7 pts, 56-63=8 pts, 64-71=9 pts, >71=10 pts)

    Symptoms and comments*

    _____

TOTAL GFMT TEST SCORE /100_____