Intervening factors in forward flexibility of the trunk in adolescents in sitting and standing position

N. M. LAMARI [1], J. A. CORDEIRO [2], L. C. MARINON. M. LAMARI [1], J. A. CORDEIRO [2], L. C. MARINO [1]

[1]Physiotherapy Service, Department of Neurological Science, Medical School of São José do Rio Preto, FAMERP, São José do Rio Preto San Paolo, Brazil
[2]Department of Epidemiology and Collective Health, Medical School of São José do Rio Preto FAMERP, São José do Rio Preto, San Paolo, Brazil

Aim. **Forward flexibility of the trunk (FFT) is used as an indicator of vertebral function and assessed using the sit-and-reach and fingertip-ground tests.**
Methods. **FFT was investigated in adolescents and comparisons were made among genders, sitting and standing positions, and low and high speed; 102 males and females (16 to 20 years of age) participated in the study.**
Results. **The position of the body and gender factor had no influence over the flexibility assessment. When executed slowly, the values obtained in the test were significantly lower; 60% of the participants were unable to reach their feet in the slow form and 50% were unable to reach their feet in the fast form. Thus, the assessment of vertebral function in adolescents should not use the ability to reach their feet as a criterion of normality. The fingertip-ground and sit-and-reach tests proved to be equally adequate. Greater height and length of limbs are associated to lower FFT values. Greater height and lower trunk-head height explain the lesser FFT in women; greater length of the lower limbs and lesser arm span explain the results for men.**
Conclusions. **Reaching the feet in either the standing or sitting position is a criterion that excludes approximately 50% of adolescents from the normality of vertebral function, whereas reaching 12 cm above the ground is achieved by 90% of the population. Therefore, the criteria for assessing FFT in adolescents need to be reviewed.**

Key words: **Joint instability - Adolescent - Spine - Psychomotor performance.**

Flexibility is an important component of physical aptitude and good health, especially forward flexibility of the trunk (FFT).[1, 2] FFT is an important part of clinical examinations and a number of methods are used for its assessment.[3] The fingertip-ground test (FGT) and the sit-and-reach test (SRT) are used to identify the flexibility of the posterior muscle chain, which is an indicator of vertebral function and parameter for progess.[3-6] The SRT is the most often employed test in studies and its accuracy was proven by Baldaci *et al.*[1, 7]

Extreme ranges of motion are characteristic of benign joint hypermobility, which is a non-pathological phenomenon that can develop into problems and predispose individuals to joint pain. This condition has dif-

Received on April 22, 2008.
Accepted for publication on July 8, 2010.

Corresponding author: N.M. Lamari, Av. Juscelino Kubitschek de Oliveira 1220, Rua 14, Casa 154, Recanto Real, 15092-259 São José do Rio Preto, San Paolo, Brazil. E-mail: neuselim@terra.com.br

ferent causes, including a hereditary disorder in collagen synthesis, which is a genetic characteristic involving multiple genes that contribute to the phenotype and degree of joint hypermobility (JH).[8]

It is well established that women have a greater range of joint motion.[5, 7] Studies have pointed out specific results regarding differences between genders.[2, 9] A study with children and teenagers found a tendency of greater FFT among females after 15 years of age.[9] However, Lamari *et al.* found no significant difference regarding this same variable in a study involving 241 individuals from a Japanese colony between 7 and 90 years of age.[2]

There is a consensus among most researchers regarding the reduction in joint mobility (JM) with age, regardless of gender.[2, 10] A study involving 1 120 male and female preschool children between four and seven years of age found that, even in this narrow age group, only 14% achieved maximum FFT.[10] However, JH was identified in just 3% of individuals of different ages in a Japanese colony, with no significant difference found between genders.[2]

Results from FFT assessments using the FGT in adults have shown that most individuals are unable to reach their feet.[4] Guedes and Guedes found that most adolescents between 15 and 16 years of age were able to reach their feet in the SRT.[9] Neither study specified the speed factor. Thus, it is necessary to consider various aspects when assessing FFT, as human beings differ with regard to primary and secondary gender characteristics as well as constitutional, anatomical, physiological and behavioral aspects, which can affect JM.[7]

Grenier, Russel and Mcgill [11] assessed FFT using the SRT and found no correlation between FFT values and anthropometric data in an analysis of 72 male and female individuals between 20 and 51 years of age. Contrarily, Lamari *et al.*[7] assessed FFT using the SRT on teenagers and found that anthropometric variables influenced flexibility values, in which a greater length of the lower limbs indicated lower FFT values for males. The same occurred with height among women. Arm span contributed toward an increase in FFT among men only during the fast movement. Body weight and trunk-head height are not correlated to FFT values.

In the identification of insufficient FFT, muscle stretching is the routine procedure used in physiotherapy clinics and gyms for the recovery of FFT.[12] The understanding of intervening factors in JM and the reliability of an adequate quantification method will contribute toward avoiding the search for incompatible physical capabilities, specifically with regard to adolescent health.[7]

Thus, the present study took into consideration the following aspects: 1) the characterisation of FFT will contribute toward the diagnosis and follow-up of health status in adolescents; 2) various intervening factors affect joint range of motion; 3) a large part of studies use the sit-and-reach test, whereas the standing reach test occurs in clinical practice; and 4) such studies do not take execution speed into account.

The aim of the study, therefore, was to characterise FFT according to gender, anthropometric characteristics, the sit-and-reach test, the standing reach test, and speed (low and high).

Materials and methods

Characterisation of the sample

Data were obtained from 102 adolescents (45 girls and 57 boys) between 16 and 20 years of age. The girls had an average age of 18.2 years (SD=1.0 year), height of 62.3 cm (SD=6.4 cm) and body weight of 59.6 kg (SD=14.8 kg), whereas the boys had an average age of 18.6 years (SD=1.1 years), height of 175.3 cm (SD=6.7 cm) and body weight of 70.6 kg (SD=12.1 kg). Individuals who refused to participate or had some physical disability were not included in the study. The study received approval from the Research Ethics Committee of the Medical School of São José do Rio Preto-SP (Brazil) on March 8, 1999 (process N. 663/99); in accordance with the forth principle of Helsinki Declaration.

Material

A wooden stadiometer with cursor, wooden bench with adjustable height and wooden box were used as measuring equipment. The box had a measuring scale attached to the anterior side, for which zero corresponded to the upper surface of the box at the stand supporting the feet; the scale reached 50 cm above and 30 cm below the foot stand, with 0.5 cm accuracy. Linear anthropometrics, such as height, arm span (AS), trunk-head height (TH), length of lower limbs (LL) and length of upper limbs (UL), were obtained with the individual barefoot and no type of clothing over the regions being measured, as detailed in the description by Lamari *et al.*[7]

Methods

The fingertip-ground test was performed at low speed (FGTS) and high speed (FGTF). The sit-and-reach test was also performed at low speed (SRTS) and high speed (SRTF).

Assessment of FFT using FGT

The FGT regards active FFT starting from a standing position, with the knees extended and held by the examiner, lower limbs extended, with one hand placed over the other such that the fingertips align. The individual leaned forward, trying to reach the greatest possible distance. The FGTS was performed without lurching, sustaining the position for two seconds. This measurement was then taken again under the same conditions, but performing the FGTF. Distance measurements above the bench were recorded as positive, whereas those beyond the bench were recorded as negative. A zero value was attributed to the surface level of the bench support. In order to reproduce the manner in which FFT is assessed in normal clinical practice, the individual was instructed how to proceed in performing the test and then executed it just once, with no prior warm-up.

Assessment of FFT using SRT

FFT was obtained through active SRT, with the individual seated over the sciatic region in front of the equipment, knees extended and held by the evaluator, with the soles of the feet against the perpendicular side of the equipment, lower limbs extended toward the surface of the foot stand, one hand placed over the other with fingertips aligned and palms turned downward. The individual leaned forward, reaching the greatest possible distance toward the feet, at low speed and without lurching. This measurement was then taken again under the same conditions, but at high speed. The distance reached was recorded to an accuracy of 0.5 cm, determined by the maximum position reached and maintained for two seconds at both speed. The examiner was positioned to the right of the individual and indicated the position reached on the scale. The result corresponded to the distance (cm) from the fingertips to the level of the soles of the feet. Measurements of the distance above the feet were recorded as positive, indicating insufficient performance in reaching the feet, whereas measurements beyond the feet were recorded as negative. A zero value was attributed when the individual touched the surface of the support. In order to reproduce the manner in which FFT is assessed in normal clinical practice, the individual was instructed how to proceed in performing the test and then executed it just once, with no prior warm-up.

Test reproducibility

Two weeks following the initial data collection, 12 individuals were selected to determine the reproducibility of the tests in both the slow and fast forms. The tests were performed a second time and compared to the initial tests using non-parametric signal analysis on the differences between measurements. There was no evidence of non-reproducibility for either the fast (P=0.29) or slow (P=1) forms.

Results

General characterisation of the sample

Negative values indicate greater flexibility, corresponding to the distance reached

beyond the feet. Values obtained from the FGTS ranged from -11 to 32 cm (mean 5.1 cm; SP: 8.1 cm), whereas values in the fast form ranged from –16 to 26 cm (mean 1.7 cm; SD: 8.3 cm). Values obtained from the SRTS ranged from -12 to 33 cm (mean 5.2 cm; SD: 7.7 cm) and values obtained from the SRTF ranged from -17 to 24 cm (mean 1.9 cm; SD: 7.8 cm).

When measurements were performed for the FGTS, 25% of the individuals reached their fingertips to a distance of 11.2 cm from the foot stand, whereas another 25% reached 0.3 cm beyond the stand. When executed in the fast form, the results of the descriptive analysis revealed that 25% of the individuals reached a maximum of 7.3 cm from the foot stand and another 25% reached 3 cm beyond the platform. When measurements were performed for the SRTS, 25% of the individuals reached a maximum of distance of 10.3 cm from their feet, whereas another 25% reached beyond their feet. When executed in the fast form, the results revealed that 25% of the individuals reached a maximum of 7 cm from their feet and another 25% reached 3 cm beyond their feet. Better results were generally achieved on the tests performed in the fast form, when approximately 50% of the adolescents were able to touch their feet. In the slow form; however, more than 60% of the individuals demonstrated an inability to touch their feet. The average flexibility value for the entire sample was more than zero centimetres.

Analysis of FFT percentages according to gender revealed that 10% of the girls were unable reach beyond 14.8 cm from their feet on the FGTS and 12.6 cm on the FGTF, whereas the limits for the boys were 15.8 cm on the FGTS and 11.6 cm on the FGTF. The Student's t test found no effect of gender on average FGTS and FGTF scores. Student's t test analyses considering a 95% confidence interval in the FFT results at the two speed according to gender revealed that 90% of the sample achieved higher FFT on the FGTS, reaching at least 11.6 cm from their feet.

Table I displays higher percentages of adolescents who were unable to reach their feet in the slow condition while standing (60.8%) and sitting (66.7%), with a statistically significant difference between those who were able to touch their feet (P<0.04 and P<0.00, respectively). In the fast form of the tests, 48% were unable to touch their feet in either position, which was not statistically different from those who were able to touch their feet (P<0.77).

TABLE I.—*Absolute and percentage frequencies of hyperflexibility (negative values) and hypoflexibility (positive values), with 95% confidence intervals, on the slow (S) and fast (F) forms of the FGT and SRT and p values for the comparison between individuals who touched their feet and those who did not.*

Variable	Gender	Hyper		Hypo		TOTAL		P
		N.	%	N.	%	N.	%	
FGT (S)	F	14	31.1	31	68.9	45	100	0.00
	M	26	45.6	31	54.4	57	100	0.30
	TOTAL	40	39.2	62	60.8	102	100	0.04
FGT (F)	F	22	48.9	23	51.1	45	100	0.50
	M	31	54.4	26	45.6	57	100	0.79
	TOTAL	53	52.0	49	48.0	102	100	0.77
TSA (S)	F	13	28.9	32	71.1	45	100	0.03
	M	21	36.8	36	63.2	57	100	0.03
	TOTAL	34	33.3	68	66.7	102	100	<0.005
TSA (F)	F	21	46.7	24	53.3	45	100	0.38
	M	32	56.1	25	43.9	57	100	0.86
	TOTAL	53	52.0	49	48.0	102	100	0.77

P values were calculated by tests for proportions with normal approximation.

TABLE II.—*Pearson's correlation coefficient between tests and P values.*

Variables	FGT (S)	FGT (F)	SRT (S)
FGT (F)	r 0.93 P 0.00		
SRT (S)	r 0.87 P 0.00	0.90 0.00	
SRT (F)	r 0.85 P 0.00	0.90 0.00	0.95 0.00

Regarding the differences between those who were able to touch their feet and those who were not, the results reveal statistically significant differences in the slow forms of the FGT and SRT for the girls and the slow form of the SRT for the boys. In the slow form, 68.9% of the girls were unable to reach their feet on the FGT and 71% were unable to reach their feet on the SRT, with statistically significant differences between those who were able to reach their feet (P<0.00 and P<0.03, respectively) On the SRTS, 63.2% of the boys were unable to reach their feet, with a statistically significant difference between those who were able to reach their feet (P<0.03).

Analysis of Pearson's linear correlation was performed between the two procedures (FGT and SRT) at both speeds. Table II shows a greater intra-test correlation (low and high speed) than inter-test correlation (FGT and SRT). The highest correlation coefficient was on the SRT between the low and high speed (r=0.95) and the lowest coefficient was between the results of the FGT at low speed and SRT at high speed (r=0.85). This indicates that 72.3% of the variability covers both tests. Pearson's correlation coefficient also determined that values for the standing and sitting positions at both speeds had strong positive correlations between each other (Figure 1); such correlations were significant, as there was a tendency of one index to accompany the other both in terms of position (sitting and standing) and in terms of speed (low and high).

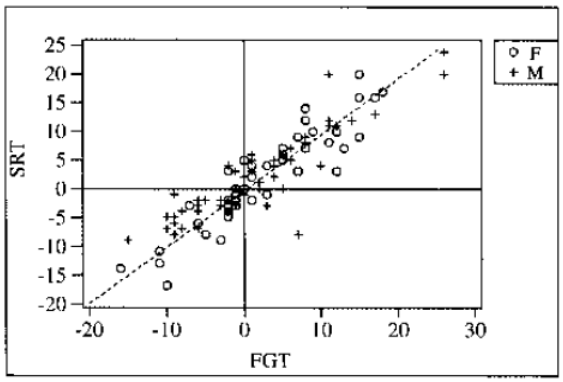

Figure 1.—Dispersion diagram of FGT x SRT in fast form (r=0.90; P<0.00).

To determine whether there was a difference between genders in the average performance of the test and speed, analysis of variance (ANOVA) was performed with the factors gender (2) x position (2) x speed (2), with repeated measurements in the latter two factors, using FFT as the dependent variable. The results indicate that neither gender nor position achieved statistical significance. However, the results reveal a statistically significant difference regarding speed, with better performances at the low speed in comparison to the high speed (slow=1.82 cm; fast=5.2 cm). None of the interactions achieved statistical significance (P<0.05).

Anterior hypoflexion and hyperflexion of the trunk

Considering the individuals who were able to reach their feet or beyond, differences were determined on the two tests under the two measurement conditions and at the two FFT execution speed (Student's t test). The results indicate that the mean differences of the measurements obtained under the two conditions by a single individual were only significant when the tests were performed in the fast form (females: P<0.04; males: P<0.00). The girls exhibited greater flexibility in the sitting position, whereas the boys exhibited greater flexibility in the standing position.

Anthropometric analysis

Among the anthropometric variables analysed, height, arm span, length of lower limbs and length of upper limbs were positively and significantly correlated to the results

of the FFT tests. Although significant, however, these correlations were weak (r=0.31 to 0.47). Multiple regression analysis of the anthropometric data on the FFT tests revealed that, for the girls, greater height or lower trunk-head height indicated a lesser FFT on the FGT as well as the SRT in the slow and fast form. For the boys, a greater length of the lower limbs indicated a lesser FFT on the FGT as well as the SRT in the slow and fast form. Greater arm span indicated a greater FFT when the SRT was performed fast. For the girls, the position of the body and test execution speed led to regression equations, as they were governed by the same components of anthropometric variation. A similar interpretation applies to the boys, with just one exception, arm span also explains the results of the SRTF.

Discussion

Tests used to assess FFT are related to the spinal column function, specifically the lumbar region due the greater prevalence of complaints in this region.[13-15] A sample of adolescents with characteristics which will portray adults seems to be adequate in the early detection of factors that will indicate physical tendencies and health levels in a young population. Among the many factors that move researchers to carry out studies in this field, the concern for primary prevention and health promotion in young people is evident.[16] In developing countries, there is no systematic program for satisfying these needs nor are there enough experiments with comparative studies, apart from a few exceptions involving only some anthropometric or motor variables in an isolated characteristic.[9, 12]

The obtainment of FFT indicators for reliable testing contributes to clinical practice as well as the research of physicians, physiotherapists and physical educators for a better understanding of good physical health in relation to FFT.[7] Therefore, it is of the interest of healthcare professionals to characterise the condition of flexibility of the spinal column of Brazilians, as cultural and social contexts reflect on physical qualities.

The present study demonstrated the inadequacy of establishing absolute values or considering either the FGT or SRT as simply touching the feet with the hands or not. Our analyses performed in two positions and at both speeds demonstrated that either in the standing position (FGT) and in the sitting position (SRT) at low speed, over 60% of the sample was unable to reach their feet under the conditions of the test.

Regarding anatomical differences and puberty, one must consider that boys generally have longer lower limbs in proportion to height.[7, 17] This difference in relation to girls is partially explained by differences in skeletal morphology, as evidenced by the results of the present study.

The analysis of the variables between the two procedures indicates a tendency for one index to accompany the other both with regard to position and speed, as the SRT and FGT achieved similar results. Differences in the FFT indexes reveal that, even in this population within a narrow age range and proportion between genders, there was considerable variation, thereby suggesting other intervening factors that are not exclusively influenced by the quantification method.[8, 11, 17] In the assessment of any characteristic, the normality concept of a variable is based on the frequency of occurrence of its values in a sample with identical characteristics. In the sample of the present study, no significant difference between genders was identified in FFT. This result may be explained by the narrow age range, as another study found that women's joints have a greater range of motion in different age groups.[11] A study involving Brazilian children and adolescents identified a tendency toward an increase in FFT among girls after 15 years of age.[9]

Gauvin, Riddle and Kothstein, Lamari *et al.* and Guedes and Guedes found comparable results to those of the present study.[4, 7, 9] The former quantified FFT using the FGT on men and women between 18 and 73 years of age and found the method to be reliable; 27% of

the participants were able to touch their feet and the remaining participants reached an average of 12.5 cm above the feet. However, the authors made no reference to the intermediate age groups, gender or execution speed of the test. It is possible that they had included individuals with JH found in the normal population or a non-significant number of adults and elderly individuals.[8] Guedes and Guedes assessed FFT among individuals between 7 and 17 years of age and found that 16-year-olds reached an average of 8.1 cm (SD=6.7 cm) above the feet, whereas 17-year-olds reached an average of 7.7 cm (SD=6 cm).[9] In the study, the procedure was performed three times, with the best result used in the analysis. This may have led to the different results obtained in the present study, as the warm-up may have provided a better FFT, as may have the high speed, which was not mentioned. Lamari *et al.* assessed FFT in adolescents and found that 10% of the more flexible individuals reached about 8 cm beyond the feet, whereas the least flexible individuals reached a maximum of 15 cm above the feet and 90% of the individuals reached 12 cm above the feet.[7] The authors suggest that the fast movement may have produced a better result due to the contribution of gravity force, weight of the trunk and activation of the flexor musculature of the trunk. Olson, Solomonow and Li discuss the contributing effect of gravity on FFT.[13]

Studies have investigated flexibility with the advance in age according to gender and found it to be greater among women.[6, 10] However, other studies found the difference to be non-significant.[2, 18] In the present study, no significant difference between genders was identified. This was possibly due to the narrow age range after the growth spurt, which may have provided more reliable results due to the fact of it being a specific population.

The present study found that gender did not modify the quantification of FFT on the two tests. It is possible that this result is related to the period of changes this age group goes through. As changes occur within a short span of time in adolescence, the results of studies that included representative sample from different age groups may have been compromised, with the exception of the studies by Lamari *et al.* and Guedes and Guedes.[7, 9] Another investigation by Lamari *et al.* may have influenced the argument presented by a number of authors for results on this aspect.[2] The small frequency of the hyperflexion characteristic among children, generically considered as the population with the greatest JM, corroborates this study, evidencing that the frequency among adolescents was lower than that among younger children. This suggests that the prevalence among adults would be even lower, as this study shows with regard to the behaviour of JM with the advance in age.[10]

Among the anthropometric variables analysed, only height, arm span and length of the limbs were positively correlated to the results of the SRT and FGT; these correlations were significant but weak. Therefore, these aspects reflect morphological changes in adolescence, which, in turn, reflect the motor skill of flexibility. However, a study involving 72 male and female individuals between 20 and 51 years of age found no correlation between FFT indexes and anthropometric data.[12] It should be pointed out that the anthropometric variables used were different than those of the present study, which hinders the discussion of the results. Guedes and Guedes [9] stress the implications of anthropometric measurements in the motor performance of flexibility and state that adolescents may be more susceptible to genetic and environmental factors.

In a prepubescent analysis, Feldman *et al.* found no correlation between the indexes obtained and adolescence.[6] Anthropometric data generally have little influence over FFT in relation to truck-head height, body weight, arm span and height, considering the previously mentioned exceptions, with structural difference between genders regarding height and body weight (both lower in girls). In the present study, differences in body weight between genders did not imply differences in FFT, thereby rein-

forcing observations by Feldman *et al.* in the determination that anthropometric measurements have little influence over FFT, apart from the exceptions mentioned.[6] According to Oliver, FFT is affected by different factors, including height and body mass.[19] However, the present study found that greater height was related to lower FFT in the girls, which is in disagreement with Oliver and, therefore, does not allow the generalisation of the results.[19]

Similar results were found in a recent study demonstrating that a greater length of the lower limbs meant a lesser FFT.[7] This is justified by the greater distance between the hands and feet, whereas a greater length of the upper limbs would mean a greater FFT. However, the study found a weak tendency with regard to a longer limb length leading to a lesser FFT. In the context of this study, it is possible that a greater length of the lower limbs (increasing the distance to the feet) reduced the possibility of total reach on these indexes. On the other hand, the same reasoning is not considered with regard to the upper limbs and arm span; as greater length does not imply a reduced distance in the total reach on these indexes. This result suggests that greater anthropometric values tend toward lower flexibility indexes.

Measurements taken under the conditions of the SRT and FGT in the slow form reduce the risk of trauma and suggest more reliable results. It was evident that most of the adolescents were unable to complete that total range of motion even under the fast condition.

There are few studies that provide quantitative data regarding FFT, especially with the use of FGT, which, despite being normally used in daily clinical practice, is not the method of choice in scientific investigation. This fact hinders comparative analyses. Therefore, further population studies by age group are suggested, as are others that involve different age groups, which could contribute toward a comparison of results and a better understanding of differences.

Conclusions

In conclusion, neither the position in the test nor gender influences FFT values. However, execution speed and anthropometric measurements produce different results.

Riassunto

Fattori che intervengono nella flessibilità in avanti del tronco negli adolescenti in posizione seduta e ortostatica

Obiettivo. La flessibilità in avanti del tronco (forward flexibility of the trunk, FFT) è un indicatore della funzione vertebrale e viene valutata mediante i test di sit-and-reach e fingertip-ground.

Metodi. La FFT è stata valutata negli adolescenti; sono stati effettuati confronti per quanto riguarda il sesso, la posizione seduta e ortostatica, e la bassa e alta velocità; 102 soggetti tra maschi e femmine (età compresa tra 16 e 20 anni) hanno partecipato allo studio.

Risultati. La posizione del corpo e il sesso non hanno influenzato la valutazione della flessibilità. Quando i test sono stati effettuati lentamente, i valori ottenuti erano significativamente inferiori; il 60% dei partecipanti non era in grado di raggiungere i piedi nella versione lenta, rispetto al 50% nella versione veloce. Pertanto, la valutazione della funzione vertebrale negli adolescenti non dovrebbe considerare la capacità di raggiungere i piedi come un criterio di normalità. I test fingertip-ground e sit-and-reach sono risultati ugualmente adeguati. Una maggior altezza e lunghezza degli arti sono associate a ridotti valori di FFT. Un'altezza maggiore e una ridotta altezza tronco-testa spiegano la minor FFT nelle donne; una maggior lunghezza degli arti inferiori e una minor lunghezza delle braccia spiegano i risultati nei maschi.

Conclusioni. Il raggiungimento dei piedi sia in posizione ortostatica sia seduta è un criterio che esclude circa il 50% degli adolescenti dalla normalità della funzione vertebrale, mentre il 90% della popolazione raggiunge i 12 cm dal pavimento. Pertanto, i criteri di valutazione della FFT negli adolescenti devono essere rivisti.

Parole chiave: Giunture, instabilità - Adolescenti – Spina dorsale - Performance psicomotoria.

References

1. Lamari NM, Marino LHC, Marino-Junior NW, Cordeiro JA. Estudo da JM generalizada e índices de FFT na comunidade japonesa de Guaíra e São José do Rio Preto. HB Científica 2003; 10(2):73-83.
2. Tsang YL, Mak MK. Sit-and-reach test can predict mobility of patients recovering from acute stroke. Arch Phys 2004;85:94-8.

3. Gauvin MG, Riddle DL, Kothstein JM. Reliability of clinical measurements of forward bending using the modified fingertip-to-floor method. Phy Ther 1990; 70:443-447.
4. Seckin U, Tur BS, Yilmaz O, Bodur H, Arasil T. The prevalence of hypermobility among high school student. Rheumatol Int 2005;25:260-3.
5. Feldman D, Shrier I, Rossignol M, Abenhaim L. Adolescent growth is not associated with changes in flexibility. Clin J Sport Med 1999;9:24-9.
6. Lamari NM, Carvalho-Marino, LH, NW, Cordeiro JA, Pellegrini AM. FFT no adolescente após o pico de velocidade de crescimento em estatura. Acta Ortop Bras 2007;15:25-9.
7. Malfait, F, Hakim, AJ, De Paepe, A, Grahame, R. The genetic basis of the joint hypermobility syndromes. Rheumatology 2006;45:502-507.
8. Guedes DP, Guedes JERP. Crescimento, composição corporal e desempenho motor de crianças e adolescentes. São Paulo: CLR Baliero; 1997.
9. Lamari NM, Chueire AG, Cordeiro JA. Analysis of joint mobility patterns among preschool children. São Paulo Med J 2005;123:119-23.
10. Grenier SG, Russel C, Mcgilll SM. Relationships between lumbar flexibility, sit-and-reach test, and a previous history of low back discomfort in industrial workers. Can J Appl Physiol 2003;28:165-177.
11. Trevisan FA, Ikedo F. Associação entre lombalgia e deficiência de importantes grupos musculares posturais. HB Científica 1999;6:20-9.
12. Olson M, Solomonow M, Li L. Flexion-relaxation response to gravity. J Biomech 2006;39:2545-54.
13. Andrusaitis SF, Oliveira RP, Barros Filho TEP. Study of the prevalence and risk factors for low back pain in truck drivers in the state of São Paulo, Brazil. CLINICS 2006;61:503-10.
14. Selkowitz DM, Kulig K, Poppert EM, Flanagan SP, Matthews ND, Beneck GJ, *et al*. The immediate and long-term effects of exercise and patient education on physical, functional, and quality-of-life outcome measures after single-level lumbar icrodiscectomy: a randomized controlled trial. BMC Musculoskelet Disord 2006,7:70.
15. El-Metwally A, Salminen JJ, Auvinen A, Macfarlane G, Mikkelsson M. Risk factors for development of non-specific musculoskeletal pain in preteens and early adolescents: a prospective 1-year follow-up study. BMC Musculoskelet Disord 2007;8:46.
16. Glaner MF. Nível de atividade física e aptidão física relacionada à saúde em rapazes rurais e urbanos. Rev Paul Educ Fis 2002;16:76-85.
17. Forléo JH, Hilário MO, Peixoto AL, Solé D, Goldenberg J. Articular hypermobility in school children in Sao Paulo, Brazil. J Rheumatol 1994;20:916-7.
18. Oliver J, Middleditch A. Anatomia funcional da coluna vertebral. Rio de Janeiro: Revinter; 1998.