DOI: 10.590/1809-2950/14095822022015

ORIGINAL RESEARCH

Reference values of ultrasonographic measurement of cross-sectional area of the multifidus muscle in children aged 6 to 9 years

Valores de referência de medidas ultrassonográficas da área de secção transversa dos músculos multífidos em crianças de seis a nove anos

Valores de referencia de las medidas ecográficas del área de sección transversal de los músculos multifidus en niños entre 6 y 9 años de edad

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ABSTRACT | This study aimed to provide reference value measures from the cross-sectional area (CSA) of the multifidus muscles in children aged 6 to 9 years old. For this purpose, 41 children (20 boys and 20 girls) were interviewed about their physical exercises practice and submitted to a unilateral ultrasonographic evaluation from the CSA multifidus muscles at rest, in the level of L5, and to an anthropometric evaluation (weight, height and MMI - muscle mass index). An average of CSA from the multifidus was found from 3,11±0,84cm^2 with no difference between sexes (p=0,37) and between sedentary children and regular exercise practitioners (p=0,68). However, it was detected a positive correlation between the CSA and the age (r=0,75; p<0,01), the weight (r=0,83), the height (r=0,75; p<0,01) and the MMI (r=0,54; p<0,01). Thus, the CSA of the multifidus of this study showed a tendency of great dimension according to the age increase, weight, height and MMI.
Keywords | Child; Muscles; Ultrasonography.

RESUMO | Este estudo teve como objetivo fornecer valores de referência de medidas da Área de secção Transversa (AST) dos músculos multífidos em crianças de 6 a 9 anos. Para tanto, 41 crianças (20 meninos, 21 meninas) foram questionadas quanto à prática de exercícios físicos e submetidas a uma avaliação ultrassonográfica unilateral da AST dos multífidos em repouso ao nível de L5 e a uma avaliação antropométrica (peso, altura e IMC). Foi encontrada uma média da AST dos multífidos de 3,11±0,84 cm^2, não havendo diferenças entre os sexos (p=0,37), e tampouco entre as crianças sedentárias e as praticantes de exercícios físicos regulares (p=0,68). No entanto, detectou-se correlação positiva entre a AST e a idade (r=0,75; p<0,01), o peso (r=0,83; p<0,01), a altura (r=0,75; p<0,01) e o IMC (r=0,54; p<0,01). Dessa forma, a AST dos multífidos, da amostra estudada, apresentou uma tendência de maior dimensão conforme o aumento da idade, peso, altura e IMC.
Descritores | Criança; Músculos; Ultrassonografia.

RESUMEN | El propósito de este estudio es ofrecer valores de referencia de las medidas del Área de Sección Transversal (AST) de los músculos multifidus en niños con edad entre los 6 y los 9 años. Para eso a 41 niños (20 muchachos y 21 muchachas) se les preguntaron acerca de la práctica de actividades físicas y los sometieron a una evaluación ecográfica unilateral de la AST de los multifidus en reposo a nivel de L5 y a una evaluación antropométrica (del peso, de la altura y del IMC). Los resultados mostraron un promedio de la AST de los multifidus con un 3,11±0,84 cm^2, además no hubo diferencias entre los sexos (p=0,37) ni entre los niños sedentarios y los practicantes de actividades físicas regulares (p=0,68). Sin embargo, se obtuvo una correlación positiva entre la AST y la edad (r=0,75; p<0,01), el peso (r=0,83; p<0,01), la altura (r=0,75; p<0,01) y el IMC (r=0,54; p<0,01). En este sentido, la AST de los multifidus en la muestra estudiada mostró una mayor dimensión a medida que aumenta la edad, el peso y el IMC.
Palabras clave | Niño; Músculos; Ecografía.

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Presentation: Sep. 2014 – Accepted for publication: May 2015

INTRODUCTION

Multifidus are deep muscles which are located on both sides of the posterior and medial region of the spine, between the spinous and the transverse processes of vertebrae, and they are organized in a way to connect one vertebra to another[1]. They extend from the cervical to the lumbar spine, the region in which they are most developed[2].

Besides that, they have a segmentary innervation, which enables those muscles to move a specific vertebral segment[3,4]. Their functions are to extend the trunk, when activated on both sides; rotate it, when unilaterally activated[5]; and promote lumbar spine stability - they are the most important muscles regarding that last task[6].

Furthermore, in recent research involving young adults, some authors have used CSA measure (Cross-Sectional Area) of the multifidus muscles as parameter to evaluate lumbar spine stability, as studies demonstrate diminished multifidus muscle CSA when lumbar spine dysfunctions occur. They include instability and lower back pain in young adults[7,8].

Ultrasonography has stood out as a method for evaluating the multifidus muscles, as they allow to evaluate muscular contraction in a non-invasive, quick, and painless way, and it provides real-time feedback on the contraction start, also allowing the measurement of the CSA of muscles[7]. That is why it is a resource which has been attracting the attention of physical therapists, both for clinical and scientific investigation purposes[9].

Several studies provide CSA measurement parameters of the multifidus in adults. An important study[9] has identified, through ultrasonographic evaluation, an average CSA measure in men and women from 20 to 69 years of age of 7.26cm^2 (standard deviation = 1.37). It has demonstrated that the CSA of multifidus was found to be larger in men, and that the correlation between age and multifidus CSA was not found to be significant. However, no reference CSA values exist in the literature for children, nor is there an indication that factors may be related to changes in the multifidus dimension in that population.

The definition of that reference value is essential to the early detection of diminished CSA, especially in children who suffer from back pain, as recent studies[10,11] have reported increased numbers of that pain profile in children and adolescents, with percentages ranging from 19.5% to 31.6%.

In association with that, the identification of associated factors may allow prevention and early treatment of possible disorders which arise from diminished multifidus CSA, which may start early in the childhood and have consequences in the adult life[12].

Therefore, this study aims to fill that gap in the literature and serve as a scientific base for future research concerning this subject. Thus, the aim of this study is to evaluate the ultrasonographic measures of multifidus muscle CSA at rest in children from 6 to 9 years of age.

METHODOLOGY

The subjects in this research and their legal guardians were informed about the aim, procedures, relevance, risks, and benefits from this study, and they signed a consent form (*Termo de Consentimento Livre e Esclarecido*) this project was tied to, as per resolution no. 466/12 of the Research Ethics Committee of the Health Ministry, under CAAE no. 0347.0.172.000-10. This study was characterized as cross-sectional.

The sample was intentional, and it comprised 41 children. Children of both genders from 6 to 9 years of age were included; they were enrolled in a private elementary school. Children who complained of lower back pain, children who had musculoskeletal and neurological disorders, children who had malformations, cognitive, or behavioral deficits which prevented a data collection step from being performed, or children with scars on their backs were excluded from the study.

After the parents/guardians authorized it, the collection of data was performed through a personal information form that was developed by the researchers, and it contained questions regarding volunteers' identification (name, gender, birth date, residential address, and telephone) and the practice of physical exercises (type and frequency).

Following that, subjects were submitted to an ultrasonographic evaluation in order to determine the multifidus cross-sectional area and an anthropometric assessment, which included the measurement of weights and heights. All those procedures were conducted by the same researcher in a private room.

A device of Aloka 500 brand with convex transducers (5MHz) was used for the ultrasonographic evaluation of multifidus. The whole procedure was performed by a properly experienced physical therapist who was qualified to handle the equipment and capture the best images.

The method from Stokes, Rankin, e Newham[9], was used in that evaluation, in which subjects were placed on their backs on an examination table. They had no shirts on and their heads were positioned in the midline of said table, in its breathing hole, with arms at the sides of their bodies. One or more pillows were placed below their hips, in order to reduce the natural lumbar spine lordosis. The rater palpated the L5 spinous process, and marked the skin with a dermographic pencil. Cranially to L5, the L4 spinous process was also identified. It was also marked with the pencil.

The device transducer was placed longitudinally at the spine midline, at the level of L4 and L5, in order that skin marks be oriented and confirmed. The transducer was rotated 90 degrees, and positioned transversely to the midline, thus producing the image of transverse processes and lumbar laminae. After that, it was moved laterally in order to obtain the image of L5 multifidus, which was measured at rest.

The image was captured from one side of the body, and CSA measures were taken through the device calipers during the exam. Multifidus CSA (cm^2) was obtained by drawing, with the cursor, an ellipsis along the interior edge of the muscle, which is delimited by the subcutaneous fascia (superiorly), the lamina (inferiorly), the spinous process (medially), and by the abrupt end of the longuissimus fascia (laterally). Two images were captured and two consecutive measures were taken, and their arithmetic average was considered for analysis.

In order to determine weight (in kilograms) a digital scale from Gama brand was used. To determine height in meters, a Tonelli stadiometer, model E120P was used. In order to determine body mass index (weight divided by squared height), the following cutout points were considered: low BMI for age (< Percentile 3); proper of eutrophic BMI (> Percentile 3 and < Percentile 85); overweight (> Percentile 85 and < Percentile 97); and obese (> Percentile 97), according to the WHO criteria[13].

Data were pre-coded and processed in a microcomputer by Epi Info 6 software, in DOS mode. Classification variables were expressed in absolute and percentage values (n; %), and quantitative variables were expressed in average values and standard deviation (average ± sd). All numeric variables were found to be normally distributed as per Shapiro-Wilk test.

Student's t Test was used in order to compare the averages of CSA multifidus measures between genders and among children who either practiced physical exercises or not. In order to compare CSA according to classifications regarding chronological age and BMI, ANOVA-OneWay test was employed. Following that, post-hoc Tukey test was applied in order to identify average differences among classifications.

For measuring the extent of association between CSA (of multifidus) and anthropometric measures (weight, height, BMI) and ages, Pearson's correlation coefficient was calculated, in which correlations were considered to be weak when coefficients were lower than 0.30, they were considered to be moderate when coefficients ranged from 0.30 to 0.7, of to be strong when coefficients were higher than 0.70. In all tests, a 5% significance level was considered.

The intrarater reliability of both CSA measures that were obtained by the researcher was examined by Statistical Package for the Social Sciences for Windows (SPSS) software, and determined by the intraclass correlation coefficient.

RESULTS

In this study, after the children and their guardians were asked to sign consent forms, and after the eligibility criteria were applied, 41 children of both genders of an average age of 7.82±0.93 years, took part in this research, as shown in the flowchart (Figure 1).

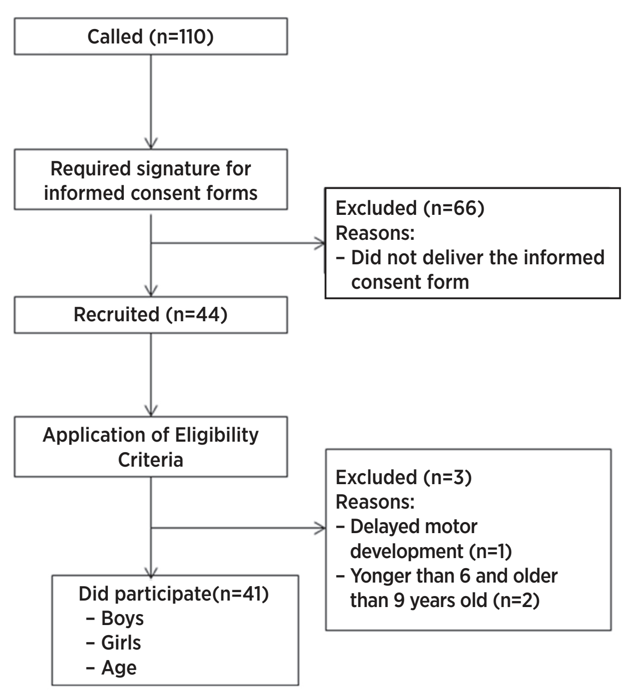

Figure 1. Flowchart of the study sample

Table 1 shows the sample characterization in regard to gender, chronological age, nutritional state, BMI classification, and practice of physical exercises.

Table 1: Sample characterization

Sample characterization	
Gender	
Masculine (n; %)	20; 48.8
Feminine (n; %)	21; 51.2
Chronological age	
6 years (n; %)	10 (24.4)
7 years (n; %)	9 (22)
8 years (n; %)	16 (39)
9 years (n; %)	6 (14.6)
Anthropometric measures	
Current Weight (Kg)*	30.29±8.99
Heigh (cm)*	1.28±0.08
BMI (Kg/cm²)*	17.93±3.43
BMI classification (b)	
Eutrophic (n; %)	21 (51.2)
Overweight (n; %)	10 (24.4)
Obese (n; %)	10 (24.4)
Practices Physical exercises	
Yes (n; %)	17 (41.5)

* Average ± Standard Deviation
BMI: Body Mass Index

Table 2: Average CSA multifidus CSA measurement as per gender, chronological age, nutritional state, BMI classification, and practice of physical exercises

Variables	CSA (cm²)	P Value
Gender		
Masculine	2,99±0,86	0,37*
Feminine	3,23±0,82	
Chronological Age (a)		
6 years	2,49±0,48	<0,00**
7 years	2,61±0,56	
8 years	3,36±0,78	
9 years	4,22±0,26	
BMI classification (b)		
Eutrophic	2,88±0,72	0,04**
Overweight	3,02±0,86	
Obese	3,68±0,88	
Practices Physical exercises		
Yes	3,05±0,81	0,68*
No	3,16±0,88	

*Student's T Test; ** One Way – ANOVA;

BMI: Body Mass Index; CSA: Cross-sectional area;

(a) Post Hoc (Tukey): 6 and 7 years (p=0.97), 6 and 8 years (p=0.07), 6 and 9 years (p=0.00), 7 and 8 years (p=0.03), 7 and 9 years (p=0.00), 8 and 9 years (p=0.03),

(b) Post Hoc (Tukey): eutrophic and overweight (p=0.89), eutrophic and obese (p=0.03), overweight and obese (p=0.17)

A multifidus CSA average of 3.11±0.84cm² was found in the studied sample. The two CSA measures that were obtained by the researcher were found to have an excellent intrarater reliability level (ICC=0.98; p=0.00).

Table 2 shows the sample characterization in regard to gender, chronological age, nutritional state, BMI classification, and practice of physical exercises. As observed, there were a significant differences for multifidus CSA according to the ages and BMI classifications. In regards to ages, differences were observed among ages 6 and 9 years (p=0.00), 7 and 8 years (p=0.03), 7 and 9 years (p=0.00), and 8 and 9 years (p=0.03), and in regards to BMI, the differences were between eutrophic and obese classifications (p=0.03)

Table 3 shows the correlation between the CSA measurement of multifidus muscles and chronological age, height, weight, BMI , and BMI classifications. Significant, strong, and direct correlation is verified between CSA and age, height, and weight, and moderate direct correlation is observed in regards to BMI and BMI classifications.

Table 3: Correlation between the CSA measurement of multifidus muscles and chronological age, height, weight, BMI, and BMI classifications

Variables	Multifidus CSA	
	R	P
Chronological age	0.75*	<0.00
Height	0.83*	<0.00
Weight (Kg)	0.75*	<0.00
BMI (g/cm²)	0.54*	<0.00
BMI classification		

BMI: Body Mass Index; CSA: Cross-sectional area

Pearson's correlation coefficient

DISCUSSION

According to the results obtained this study, the children of 6 to 9 years of age with average height of 1.28±0.08cm, and weight of 30.29±8.99kg, ,were verified to have average multifidus CSA of 3.11±0.84cm² at rest. The average increased with age, weight, height, and BMI, and no statistically significant differences were found between genders or in regards to the practice of physical exercises.

In the surveyed literature, no multifidus CSA reference values for that age range were found to exist, which highlights the singularity of this study. However, several studies[9,14,15,16] express reference parameters for multifidus sizes in adults. Stokes, Rankin, and Newham[9] identified an average multifidus CSA measure of L5 in men (8.91±1.68 cm²) and women (6.65±1 cm²) from 20 to 69 years of age, as well as Watson et al.[14], who also found that average in men (7.58±1.51 cm^2) and women (6.01±0.70cm^2) in the same age range.

The differences between CSA in this study, conducted with children, and the one of previously published studies with adults is regarded to the divergent age ranges of samples, as the literature that related to that subject states that there is progressive muscle mass increase with chronological age, from childhood to adolescence[17], and it is found to have more significant gains during puberty[18] - those values tend to remain unaltered in the adult phase.

That can also explain the fact that the studies by Stokes et al.[9], and Watson et al.[14] have respectively found no or weak correlations between CSA and age, unlike the results in this study, which were found to present strong correlation among variables.

Besides the age, in this study, a positive direct Relationship was found between multifidus CSA and measures of weight, height, and BMI, which is due to the fact that the osteomyoarticular system is still under development in children. Thus, the progressive increase in height, weight, and consequently in BMI in childhood and adolescence is expected to cause higher overburden to the trunk, thus directly and indirectly influencing the forces which play roles in the backbone, hence contributing, to a certain extent, to the adaptive muscular growth.

On the other hand, in studies conducted with adults, there still seems to be a lack of consensus, as Stokes et al.[9] found to significant correlations between the multifidus size and general anthropometric measures, which contradict the reports from Hides et al.[15], who found significant positive relationships of multifidus CSA of L4 with height and BMI. To Stokes et al.[9], it was hard to explain those differences; however, they highlight that their sample had an average weight above the one from Hides et al.[15].

In regards to gender, several studies state that there is a statistically significant relationship with multifidus CSA. Hides et al.[15], when examining that correlation in adults, observed that men have significantly higher CSAs than women (6.15cm^2 vs 5.60cm^2), which is similar to the results obtained by Stokes et al.[9], which was expected due to the differences in the body composition across genders.

Nonetheless, in this study that association was not found, as the volunteers were children from 6 to 9 years of age who have not reached puberty yet (a period which is linked with quick body changes, related to sexual maturation). That result is consistent with previous studies[19.20], which concluded that, before puberty, there is not significant difference in the size of muscles across genders. That difference is observed around 13-15 years, and it varies according to specific muscles.

In regards to the practice of physical exercises, Hides, Richardson et al.[6] verified significantly increased multifidus CSA in adult patients with lower back pain, after specific exercises for those muscles. However, this study has not found that correlation, as the physical exercises that were reported by the children do not cause the specific recruitment of the multifidus muscles.

A significant effect from the practice of physical exercises on multifidus CSA could only be visualized if children performed exercises that were specific for those muscles[21], such as spinal segmental stabilization. That technique could help answering that question in children and adolescents.

This study has limitations which relate to the fact that multifidus evaluation was only conducted at the level of L5 at rest. The study was chosen to be focused on that region, as it has been shown to be the biggest among the muscles in L2-S1, and for showing the best potential to provide dynamic stability to its segment[9,16]. The lack of measurements regarding the size of multifidus muscles during contraction is due to the fact that children have trouble voluntarily controlling those muscles, which rendered the evaluation of that measure impossible.

Besides that, the sample size was small, although it was comparable to other similar investigations[13,16]. Thus, despite the sample having been varied in regards to gender, age, and anthropometric parameters, future studies must seek equally diversified and larger samples, and include the measurement of multifidus during contraction, which is shown to be important in order to evaluate their function and to guide therapeutic decisions[23].

CONCLUSION

The children of 6 to 9 years of age with average height of 1.28±0.08cm, and weight of 30.29±8.99kg, who were evaluated in this research were found to have average multifidus CSA of 3.11±0.84cm^2 at rest, whose measures increased with age, weight, height, and BMI. The multifidus CSA measures in this age range were similar to both genders, and they have not varied in regards to the practice of physical exercises. Thus, this study allowed, in an unprecedented way, providing reference measures for the multifidus muscles in that age range, for both genders. Besides that, it reinforced the use of ultrasonography by physical therapists, as an effective and painless way to evaluate the multifidus muscles, both for research and clinical practice purposes, in order to early detect abnormalities in children.

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