RELIABILITY AND USEFULNESS OF BULB DYNAMOMETER FOR MEASURING HAND GRIP STRENGTH IN PRESCHOOL CHILDREN

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Original scientific paper

Abstract
The aim of this study was to examine the reliability and usefulness of baseline pneumatic squeeze (bulb) dynamometer for measuring hand strength in preschool children. A total of 95 preschool children aged 5–7 years participated in the study. The equipment used in this study includes a baseline pneumatic squeeze bulb dynamometer (Baseline, USA). Non-significant differences (p > 0.05) were observed between testing sessions for Dominant (ES = trivial; p = 0.87) and Non-dominant hand (ES = trivial; p = 0.61). High test-retest reliability (ICC > 0.90) was observed for both measures. However, CV% was above 5% in both, Dominant and Non-dominant hand. The typical error for Dominant (TE = 3.05 Kpa) and Non-dominant hand (TE = 2.85 Kpa) was greater than the presumed SWC (SWC = 1.80 Kpa and SWC = 1.87 Kpa), consequently these measures were rated as "marginal". We observed a higher variation in handgrip strength in the group of children aged 5 to 7 years old, which might be explained by the smaller sample size compared with the other studies. Moreover, possible differences in hand sizes could also contribute to a higher variation in this age group. Future studies should also increase the sample size, especially in children with different hand sizes.

***Key words**: strength, measurement, children, metric characteristics.*

Introduction

The preschool period is very important for the formation of the personality. During this period children build the motor abilities and later, they only learn a variety of modifications and adjustments to various situations in life (Bala, 2002). Measuring motor skills in preschool children is a complex and difficult task. When it comes to assessing most of motor skills in young children, it is not the most accurate and the validity of the instruments applied in this age group is highly questionable (Malina, 2004). There are some concerns about whether standardised tests work well in young children. The younger the child, the harder it is to get valid results. There is increasing evidence that muscular strength is a marker of health in childhood and adolescence (Smith et al., 2014). Concerning the muscular strength, handgrip strength has been measured in preschool children (Bear-Lehman, Kafko, Mah, Mosquera & Reilly, 2002; Zuidam, Selles, Stam & Hovius, 2008), but there is no strong evidence whether it is associated with health outcomes in this population. The handgrip strength test is a relatively simple test that has been widely used in experimental and epidemiological studies in youth (Castro-Pinero et al., 2010; Ortega, Silventoinen, Tynelius, & Rasmussen, 2012; Ruiz et al., 2006; Ruiz et al., 2011). The Jamar (Lafayette Instrument, Lafayette, United States) dynamometer has been recommended by the American Society of Hand Therapists and has been adopted in many studies as an excellent instrument for the measurement of hand grip strength (Roberts et al., 2011; Ferreira et al., 2011).

The bulb dynamometer is smaller and lighter than instruments frequently cited in the literature with a fact facilitating the recording of isometric strength and its use by children. Despite concerns over pressure being less reliable than force as a measurement (Innes, 1999), this was not supported by Ward & Adams, (2007) who found that bulb dynamometer was seen to be as reliable as the dynamometers in recording hand force when examining test-retest reliability. Link, Lukens & Bush (1995) established normative data for hand grip strength in children aged 3 to 6 years using a Martin Vigorimeter, which is similar to a bulb dynamometer. Therefore, more complete reference data of hand grip strength in healthy children measured with the bulb dynamometer are necessary to permit the use of this instrument in clinical practice. Zuidam, Selles, Stam & Hovius (2008) compared the reliability of a Jamar-like dynamometer (Lode BV, Groningen, The Netherlands) and the Martin Vigorimeter (Elmed, Addison, United States) (bulb design) for the measurement of grip strength in children. As expected, smaller children needed a wider grip to use the Jamar-like dynamometer. However, both instruments showed good to excellent reliability. The Jamar hand dynamometer is probably the dynamometer that is most used in the clinical setting and research. However, we decided to use the baseline pneumatic squeeze (bulb) dynamometer based on some previous recommendations. Moreover, research with squeeze (bulb) dynamometer for measuring grip strength in preschool children is limited.

Therefore, the aim of this study was to examine the reliability and usefulness of baseline pneumatic squeeze (bulb) dynamometer for measuring hand strength in preschool children.

Materials and methods

A total of 95 preschool children aged 5–7 years participated in the study (Table 1). Children were recruited from several public kindergartens located in autonomic Vojvodina. Children were healthy and free of any limbs injuries. Parents or legal guardians provided written informed consent. The study protocol was approved by the Committee for Research Involving Human Subjects at the faculty of sport and physical education in Novi Sad and in accordance with the ethical standards (Declaration of Helsinki, revised in 2013).

Table 1 Descriptive characteristics of preschool children.

Age (years)	5.63±1.04
Body height (cm)	116.91±7.40
Body mass (kg)	21.19±4.25
BMI	18.26±1.61

The equipment used in this study include a baseline pneumatic squeeze bulb dynamometer (Baseline, USA). The participants received thorough instructions after which they were also allowed to practice the tests. Subjects received verbal encouragement during the tests. Each participant was positioned in a standard position as recommended by the American Society of Hand Therapists. Two successive bilateral power grip strength measurements were recorded. The dominant hand was assessed first. To prevent fatigue occurring, a 15-second rest period between each measurement was given. The dynamometer was supported slightly by the examiner to prevent any accidental falls. All tests were performed by the same examiner. The statistical analyses were carried out using SPSS 19.0 program for Windows (SPSS, Inc, Chicago, IL, USA). Descriptive statistics were generated for all variables.

Means and standard deviations (SD) with 90% confidence interval limits (90% CI) were used to represent centrality and spread of data. The normality assumption was checked using Shapiro-Wilk test and all variables showed a normal distribution. Standardized differences in mean were calculated to determine the magnitude of the change. According to Hopkins et al. (2001) effect size (ES) magnitudes of change were classified as trivial (>0.2), small (0.2-0.5), moderate (0.5-0.8); large (0.8-1.60) and very large (>1.60). Reliability of the change in the mean between trials was determined using intraclass correlation coefficient (ICC), typical error (TE) expressed as coefficient of variation (CV%) and smallest worthwhile change (SWC); an Excel spread sheet supplied by Hopkins (Hopkins, 2007) was used for the calculations. ICC values of 0.1, 0.3, 0.5, 0.7, 0.9 and 1.0 were classified as low, moderate, high, very high, nearly perfect and perfect, respectively. The following criteria was used to declare good reliability: CV < 5% and ICC > 0.69 (Buchheit et al., 2011). Appropriate performance usefulness indicators in accordance to the noise of the test result and measurement uncertainty (Hopkins, 2004) was assessed via the magnitude of the SWC. A comparison of SWC (0.2 multiplied by the between-subject SD, based on Cohen's effect size) to TE was used to establish the usefulness of a given dependent variable as follows: "Marginal" (TE >SWC), "OK" (TE = SWC) and "Good" (TE < SWC).

Results

Reliability

Similar Dominant hand (test = 34.1 ± 9.1 Kpa; retest = 34.0 ± 9.8 Kpa) and Non-dominant (test = 29.9±9.5 Kpa; retest = 29.2±10 Kpa) values were observed between handgrip testing sessions. Non-significant differences ($p > 0.05$) were observed between testing sessions for Dominant (ES = trivial; $p = 0.87$) and Non-dominant hand (ES = trivial; $p = 0.61$) as observed in Table 2. High test-retest reliability (ICC > 0.90) was observed for both measures. However, CV% was above 5% in both, Dominant and Non-dominant hand.

Test usefulness

The TE for Dominant (TE = 3.05 Kpa) and Non-dominant hand (TE = 2.85 Kpa) was greater than the presumed SWC (SWC = 1.80 Kpa and SWC = 1.87 Kpa), consequently these measures were rated as "marginal".

Table 2 Reliability measure values for Handgrip strength in preschool children.

Dominant hand (Kpa)		Non-dominant hand (Kpa)
ES	0.06 (Trivial)	0.11 (Trivial)
Diff (90%CI)	-0.01 (-0.07; 0.08)	-0.06 (0.0; 0.13)
ICC (90%CI)	0.90 (0.86;0.93)	0.92 (0.88;0.94)
TE (90%CI)	3.05 (2.74;3.44)	2.85 (2.54;3.26)
CV% (90%CI)	9.6 (8.6;10.9)	10.3 (9.1;11.1)
SWC%	1.80 (5.3)	1.87 (7.1)
Rating	marginal	marginal

Legend: ES - effect size; ICC - intraclass correlation coefficient; TE - typical error of measurement; CV - Coefficient of variation; SWC - smallest worthwhile change; CI - confidence interval.

Discussion and conclusion

The handgrip strength test is currently used worldwide because it is a relatively cheap test that gives practical information on muscle, nerve, bone, or joint disorders (Adams et al., 2004). Given the importance of strength for children, and the lack of reliability data for commonly used strength measures in preschool children, this study evaluated the reliability of handgrip test in preschool children. The present study is an attempt to provide information about better standardization in the procedures and to determine the reliability. Without standardization and reliability, the

measurement error may be too large to detect actual changes in strength after an intervention, for instance. Findings showed both, the dominant and non-dominant hand had low levels (i.e. CV% >5%) of reliability for the handgrip test, which suggests that these tests are not reliable. However, the data obtained for the 95 children enabled the authors to establish reference values of handgrip strength measured with a bulb dynamometer in children 5-7 years of age. Our data support the findings that measuring pressure has been less reliable than force as a measurement (Innes, 1999). The criticism of pneumatic instruments, comes from the fact that the grip pressure and not grip strength is measured (Stephens, Pratt, & Parks 1996).

This criticism is based on the pressure measurement being dependent on the surface area over which the force is applied. If the surface area is small, then the force applied will register as a greater pressure than if the same force is spread over a greater surface area (Stephens et al., 1996). A person's hand size may therefore influence the grip pressure recorded (Richards, Olson & Palmiter-Thomas, 1996). Preschool children have smaller hand sizes and lower handgrip strength compared with older children, adolescent and adults (Ploegmakers, Hepping, Geertzen, Bulstra & Stevens, 2013). Because of these differences, it can be speculated that each age group may need a different optimal grip span when measuring handgrip strength (Ortega et al., 2015). We do not know whether handgrip strength levels would have been higher at smaller grip spans because the dynamometer used in the present study did not allow change in grip spans setting.

It was reported in the literature that the dominant hand was stronger than the non-dominant hand (Molenaar et al, 2010; Sartorio, Lafortun, Pogliaghi & Trecate, 2002). Sartorio et al. (2002) found that grip strength of the dominant hand was 10% greater compared with the non-dominant and in both genders and for all ages. In the present study, we did not analyse the participants by gender and age and difference between dominant and non-dominant hands for all ages, however the difference in grip strength between hands is obvious. To the authors' knowledge, research on the influence of bulb size on grip strength in preschool children is limited. This is an issue for further research as the purpose of the present study was not to investigate this question.

Also, it is important to note that the bulb dynamometer has not been validated in the international scientific literature. We observed a higher variation in handgrip strength in the group of children aged 5 to 7 years old, which might be explained by the smaller sample size compared with the other studies. Moreover, possible differences in hand sizes could also contribute to a higher variation in this age group. Future studies should also increase the sample size, especially in children with different hand sizes. The study sample was not designed to statistically represent the whole population of Serbian preschool children; however there are no reasons to believe that the children participating in this study are different from other Serbian children of the same age. It must be borne in mind that different kinds of dynamometers and hand size might change the results. We do not know whether these findings can be directly transferred to our results.

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POUZDANOST I KORISNOST PNEUMATSKOG (BULB) DINAMOMETRA ZA MJERENJE SNAGE RUKE U PREDŠKOLSKOJ DJECI

Sažetak

Cilj ovog rada bio je ispitati pouzdanost i korisnost osnovnog pneumatskog dinamometra (bulb) za mjerenje snage ruke kod predškolske djece. U istraživanju je sudjelovalo ukupno 95 djece predškolske dobi od 5 do 7 godina. Oprema koja se koristi u ovoj studiji uključuje osnovni pneumatski dinamometar (Baseline, USA). Nisu zabilježene značajne razlike (p> 0,05) između sesija za dominantnu (ES = trivijalan, p = 0,87) i nedominantnu ruku (ES = trivijalan, p = 0,61). Za obje mjere zabilježena je visoka pouzdanost testa (ICC> 0,90). Međutim, CV% je iznad 5% u dominantnoj i nedominantnoj ruci. Tipična pogreška za dominantnu (TE = 3,05 Kpa) i nedominantnu ruku (TE = 2,85 Kpa) veća je od pretpostavljenog napretka SWC (SWC = 1,80 Kpai SWC = 1,87 Kpa), pa je ta mjera ocijenjena "marginalnim". U skupini djece u dobi od 5 do 7 godina uočen je veći varijabilitet rezultata u snazi hvata, što se može objasniti manjom veličinom uzorka u usporedbi s ostalim studijama. Štoviše, moguće razlike u veličinama ruku također mogu pridonijeti većoj varijaciji u ovoj dobnoj skupini. Buduće studije također bi trebale povećati veličinu uzorka, posebno u djece s različitim veličinama ruku.

Ključne riječi: *jakost, mjerenje, djeca, metrijske karakteristike.*

Received: July 19, 2017
Accepted: August 16, 2017
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