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Hand grip strength as an indicator of Bone Mineral Density and hand function in preschool children

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Abstract

*Hand grip strength is one of the best indicators of the overall strength of the upper limb and it is evaluated as a component of hand function upper limbs play an important role in subject's daily life.use of HGS is a single, simple and inexpensive method for assessing general muscle strength, function and bone health in children which is important to identify children who may be at risk of poor mineral accretion or future risk of osteoporosis due to low bone mineral density**purpose**of this studyTo investigate correlation between bone mineral density with both hand grip strength and hand function in preschool children and to search about cheap, valid indicator of bone density in children.**Subjects and Methods**:Sixty normal preschool children, with age ranging from 4 to 6 years old both sexes participated in this study, children were selected from nurseries and charitable orphanages at urban region of Cairo Governorate; namely (Awladi).Each child was evaluated individually byusing Peabody Developmental Motor Scale (PDMS-2) to determine standard scores of visual-motor integration subtestand age equivalent for fine motor activities and Baseline pneumatic squeeze handheld dynamometer todetect maximum hand grip strength, Bone mineral density was assessed by DEXA at National Research Center for all children **Results:**The results of this study revealed significant correlation between hand grip strength with bone mineral density and hand function **Conclusion**: hand grip strength could be used as a predictor for bone density and hand skill in preschool children*

***Key words**: Hand grip strength, Bone Mineral Density, Peabody Developmental Motor Scale (PDMS-2),Baseline pneumatic squeeze handheld dynamometer.*

I. Introduction

Hand is considered to be the most sophisticated and differentiated musculoskeletal device in the human being. Full characteristic and adequate power of the hand are preconditions for dealing with the daily life activities. Hand energy has been recognized as an essential component predicting not only diseases in musculoskeletal ailments such as rheumatoid arthritis, alternatively also bone mineral density, and the opportunity of falls and fractures in osteoporosis(1).The handgrip strength test is fairly simple test that has been widely used in experimental and epidemiological studies in youth. It is regarded as a good overall strength indicator for young and it seems to be

valid and reliable. However this test can be affected by factors such as age, position of joint angles, grip span and hand size of individual. HGS is a relatively inexpensive test that provides practical data on muscle, nerve, bone, or joint disorders.It has also been related in children and adolescents to bone mineral density, impaired cognition, and risk factors for cardiovascular disease. Handgrip intensity in pre-school children has also been measured, but it is not clear if it is correlated with health outcomes in this population. Moreover, in these earlier studies, no specific information about the protocol was given. It was shown that when measuring the handgrip strength in adults, adolescents and children aged 6 years and older, the dynamometer should be calibrated to an acceptable grip period. In addition, in both genders of any age, except in adults, the optimal grip span was influenced by hand size. When measuring handgrip strength compared to older populations, preschool children are expected to need a different optimal grip span(2).Grip strength is used considerably in the assessment of hand function. Because it is directly affected through the neural, muscular and skeletal systems, grip strength is used in the evaluation of sufferers with a giant vary of pathologies that impair the extremities, together with rheumatoid arthritis, muscular dystrophy, stroke osteoarthritis, tenosynovitis and congenital malformations. Grip strength measurements additionally have a hooked up function in deciding therapy efficacy, such as in the contrast of unique wrist orthoses, the effect of hand exercises in rheumatoid arthritis, and healing after trauma. Also, they are used as an effect measure after many special surgical interventions. Grip power measurements supply a nicely mounted and objective score that is reflective of hand function and that is easily and shortly obtainable through a range of distinct health professionals(3).The physical aspects of the hand function gradually develop when the human being emerges at pre-school age. In response to environmental and socio-cultural needs, a young child integrates the physical components of the hand into the different hand functional skills. It is therefore rather important to study how the hand function develops and adapts to daily requirements. An accurate evaluation enables a therapist to plan and provide adequate intervention, as well as assess progress with the therapist(4). In early childhood, bone health is particularly important because children with low bone mineral density (BMD) are at a higher risk of bone fractures. Although BMD is effective in older children for physical activity and consumption of both calcium and vitamin D, there is little research on the determinants of good early childhood bone health(5).Dual-energy X-ray absorptiometry (DXA) has been advocated with the beneficial resource of the International Society for Clinical Densitometry (ISCD) as a producer new criterion for measuring bone mineral content (BMC) and bone mineral density (BMD). This dimension method has immoderate precision, accuracy, speed, low radiation exposure, ease of use and a sturdy correlation with hooked up methods.DXA is the most broadly used bone densitometry technique in children. (6).Factors that affect bone mineral accrual during development are genetics, sex, race, hormonal factors, diet, mobility, weight bearing activity. Daughters of women who endured distal end of radius fracture had lower femoral neck and lumbar spine areal bone mineral density (aBMD) compared to controls, supporting the role of genetic and environmental factors in bone formation (7).

The aim of this study was to examine the correlation between Hand grip strength withboth bone mineral density and hand function.

II. Methods

Participants

Sixty preschool children aged 3–6 years (53% boys; n=32, 47% girls n=28) participated in the study. Children were recruited from Orphanages and nurseries, Cairo Governorate, Egypt Children were healthy and free of any injury or impairments in the upper limbs. Bone Mineral Density was assessed inside Radiological Unit at National Research Center, hand grip strength and hand function was evaluated in Out-clinic of Faculty of Physical Therapy, Cairo University. A comprehensive description of the purpose of the study was given to either their parents or teachers. Simple questionnaire was performed included: (1) the information on participants' characteristics including gender, age (2) the dietary intake assessment and vitamin D or calcium supplementation; (3) physical activity or sports participation.One parent or teacher provided written informed consent.

Procedures

Measurement of handgrip strength:

Apparatus

Maximal handgrip strength was evaluated using Martin Vigorimeter which used to measure the spherical grip strength of each child. This instrument has a three-size pneumatic dynamometer with rubber bulbs (diameters of 4 cm, 5 cm, and 6 cm). The smallest bulb had been found to be ideal for the scale of all children's hands. The air pressure inside the bulb was recorded through a rubber connection in kilopounds per square centimetre (1 kp/cm2 = 98.1 kPa) on a manometer. The dial on the manometer had an arrow that rotated and stopped at thehighest point of pressure exerted, and then maintained the reading to allow for accurate recording. The Martin Vigorimeter was calibrated in kPa's.

Martin Vigorimeter

Child position

All children were seated in appropriately sized chairs that allowed their feet to be flat on the floor. The upper extremity to be tested was positioned so that the shoulder was adducted and neutrally rotated, the elbow was

flexed at 90°, the forearm was neutral, and the wrist was in 0° to 30° of extension, maintained by resting the elbow and forearm on the table. Each child did the test 3 trials with rest in between. The mean of 3 trials of the handgrip strength obtained with each hand was calculated. The children were encouraged to do their best when performing the tests.

Measurement of Bone Mineral Density

Apparatus

Norland XR-46

Dual energy x-ray absorptiometry 'DEXA' (Norland XR-46, version 3.9.6/2.3.1, USA) The Dual Energy x-ray absorptiometry 'DEXA' (Norland XR-46, version 3.9.6/2.3.1, USA) is a pencil beam X-ray bone densitometer at the Medical Excellence Research Center 'MERC' of the National Research Centre which uses two different energy levels produced by an energy tube to estimate bone mineral content (BMC) and bone mineral density (BMD).The densitometer produces ionizing radiation in the form of X-rays and uses laser radiation to position scans; however, the radiation exposure is so low that no shielding of the room or of health technologists is required.

Procedure

The name of the child, date of birth, sex, weight and height were inserted into the software of the device after calibration of the device. As every scan is being performed, the test has been clarified in more detail. The therapist told the child of the assessment and role. It took a few minutes to position the child correctly for each scan and another few minutes to apply the scans. All metal objects or heavy clothes were removed. The child lied in the supine lying position, the head in the mid position with the participant maintaining the exact distance between the arms and legs according to the manual of the system instructions, the child asked not to move entirely, and the DEXA arm moved from the head to the toes.

Measurement of hand function

Peabody Developmental Motor scale-2

It was developed by *Folio and Fewell*(8) to test gross and fine motor abilities. It contains six sub-tests: reflexes, stationary, locomotion, manipulation of objects, grasping and Visual-Motor Integration (Vi) This subtest tests the capacity of a child to use his or her visual perceptual abilities to perform complex tasks of eye-hand coordination, such as reaching and grasping an object, building with blocks, and copying designs.Every child was asked to sit on a chair that allowed him/her to position his/her feet on the floor comfortably. The table height should be sufficient to adjust with the height of the child that helps the investigator to achieve the most accurate scores in PDMS-2, the child required to sit opposite the therapist or side by side at the same level of elbow. Copy square, cutting circle, building steps, connecting dots, Cutting Square, building pyramids, folding paper, and coloring between lines were evaluated for each child according to his/her age.

Scoring

Items of the PDMS-2 were scored with a 3-point score (0, 1, and 2); a score of 2 is assigned when the child performs the item according to the specified item criterion, a score of 1 indicates that the behavior is emerging but that the criterion for successful performance is not fully met, and a score of 0 indicates that the child cannot or will not attempt the item or that the attempt does not show that the skill is emerging.

Data analysis:

Descriptive statistics were utilized in presenting the subjects demographic and clinical data. Pearson Correlation Coefficient was conducted to investigate the correlation between hand grip strength, bone mineral density and Peabody scores of visual-motor integration subtest. For significant correlation, simple linear regression was conducted to produce a prediction model between variables. Unpaired t test was conducted for comparison of hand grip strength, bone mineral density and Peabody scores of visual-motor integration between boys and girls and between 4-5 and 5-6 years age groups The level of significance for all statistical tests was set at $p < 0.05$. All statistical measures were performed through the statistical package for social sciences (SPSS) version 25 for windows.

III. Results

Subjects characteristics:

Sixty preschool children participated in this study participated in this study. 28 (7%) children were girls and 32 (53%) were boys*table (1).*

Table 1.Participant characteristics.

	Mean ± SD	**Maximum**	**Minimum**
Age (years)	5.03 ± 0.82	6	4
Weight (kg)	19.1 ± 2.67	23.5	15
Height (cm)	105.63 ± 8.2	118	93
BMI(kg/m²)	17.13 ± 1.67	21.94	11.89

SD, Standard deviation

The correlation between hand grip strength and BMD of the dominant upper limb was moderate positive significant correlation while that of the non-dominant upper limb was weak positive non-significant correlation and correlation between hand grip strength and Peabody scores of visual-motor integrations was strong positive significant correlation for both dominant and non-dominant sides*table (2)*.

Table 2: Correlation between hand grip strength,BMD and Peabody scores of visual-motor integrations:

	Hand grip strength Dominant upper limb		**Hand grip strength Non-dominant upper limb**		**Peabody scores of visual-motor integrations**	
	r - value	**P- value**	**r - value**	**P- value**	**r - value**	**P- value**
BMD of Dominant upper limb	0.367	0.004			0.436	0.001
BMD of NON Dominant upper limb			0.19	0.14	0.324	0.01
Hand grip strength Dominant upper limb					0.756	0.001
Hand grip strength Non-dominant upper limb					0.763	0.001

r value: Pearson correlation coefficient; p value: Probability value

There was no significant difference in BMD and hand grip strength of the dominant and non-dominant upper limb between boys and girls. There was a significant increase in Peabody score of girls compared with that of boys.

There was no significant difference in BMD of the dominant and non-dominant upper limb between 4-5 years and 5-6 years age groups while there was a significant increase in hand grip strength of the dominant and non-dominant and Peabody score of 5-6 years age group compared with that in 4-5 years age group*table (3)*.

Table 3. Mean BMD, hand grip strength and Peabody score of boys and girls:

	Boys	Girls			
	Mean ± SD	**Mean ± SD**	**MD**	**t- value**	**p value**
BMD (gm/cm²)					
Dominant upper limb	0.43 ± 0.08	0.48 ± 0.09	-0.05	-1.82	0.07
Non-dominant upper limb	0.34 ± 0.08	0.38 ± 0.06	-0.04	-1.71	0.09
Hand grip strength (kPa)I					
Dominant upper limb	31.97 ± 3.28	32.26 ± 3.36	-0.29	-0.31	0.75
Non-dominant upper limb	30.02 ± 2.68	30.59 ± 3.28	-0.57	-0.7	0.48
Peabody scores of visual-motor integrations	139.93 ± 2.61	142.03 ± 2.34	-2.1	-3.15	0.003

SD, standard deviation; MD, mean difference; p-value, probability value

Table 4. Mean BMD, hand grip strength and Peabody score of 4-5 years and 5-6 years age groups:

	4-5 years	5-6 years			
	Mean ± SD	**Mean ± SD**	**MD**	**t- value**	**p value**
BMD (gm/cm²)					
Dominant upper limb	0.44 ± 0.1	0.47 ± 0.04	-0.03	-1.01	0.31
Non-dominant upper limb	0.363 ± 0.09	0.360 ± 0.05	0.003	-0.1	0.91
Hand grip strength (kPa)					
Dominant upper limb	30.19 ± 1.71	35.98 ± 2.02	-5.79	-11.68	0.001
Non-dominant upper limb	28.54 ± 1.57	33.76 ± 1.62	-5.22	-12.12	0.001

Peabody scores of visual-motor integrations	139.61 ± 2.13	143.61 ± 0.86	-4	-8.21	0.001

SD, standard deviation; MD, mean difference; p-value, probability value

Hand grip strength can significantly predict the BMD and Peabody score in dominant upper limb *table (5).*

Table 5:Linear *regression model of BMD and Peabody score from hand grip strength:*

Linear regression model of BMD from hand grip strength in the dominant side					
R^2		**B**	**p value**	**95.0% CI**	
				Lower	**Upper**
0.13	**Constant**	0.14	0.18	-0.07	0.35
	Hand grip strength	0.01	0.004	0.003	0.01
Linear *regression model of Peabody score from hand grip strength*					
R^2		**B**	**p value**	**95.0% CI**	
				Lower	**Upper**
0.13	**Constant**	120.7	0.001	116.05	125.35
	Dominant hand grip	0.2	0.497	-0.39	0.8
	Non-dominant hand	0.45	0.181	-0.21	1.12

IV. Discussion

The results of current study showed positive significant correlation between hand grip strength and bone mineral density in dominant hand ,but non-significant in non-dominant hand , this result is accordance with some research which suggested that the relation between grip strength and bone mass is not only site-specific, but also systemic(9). Low grip strength has relation with decreased BMD on the spine and femoral neck which associated

with an increased risk of incident vertebral fracture in women(10). A significant correlation between hand BMD and grip strength was found in healthy men`s dominanthand more than non-dominant hand(11).There was a greater risk of osteoporosis in women with lower hand grip strength and lower body mass index. Hand grip strength was also negatively linked to osteoporosis among adults, and previous fragility fracture was positively linked. A higher risk of osteoporosis was present in adults with lower hand grip strength or past fragility fracture.Therefore, hand grip strength was negatively related to osteoporosis in both females and males. The lower the hand grip strength, the higher the risk of osteoporosis was(12). Pre-school children aged 36-71 months; BMD was positively linear in relation to length/height and was inversely linear in relation to BMI. BMD was positively associated with weight in infants (0-35 months), but not significantly correlated in pre-school children (36-71 months) (13).

Our study showed that was strong positive significant correlation between hand grip strength and Peabody scores of visual-motor integrations for both dominant and non-dominant sides which corresponding withreview of some studies which suggested decreased grip strength over thepast 3 decades and concluded that hand functions (eg, grip strength and manual dexterity) might be changed over generations and across countries(14).

Provided gender and age, in boys and girls, there was no significant difference in BMD and hand grip strength of the dominant and non-dominant upper limb between boys and girls, this aligns with the findings of Robertson and Deitz(15) De-Smet andVereammen(16), and Häger-Ross and Rösblad(17), whofound no differences in grip strength for those younger than 7 years(18).

Current study showed that hand grip strength can significantly predict the BMD and Peabody score in dominant upper limb and that agreed with studies that described that hand grip strength is used as a tool to predict health throughout an individual’s lifetime. No previous studies have investigated normative values of hand grip strength in pre-school children.Hand grip strength is an indicator of total body strength, an objective physical skill test, and a reliable predictor of work capacity, disease/injury level, and outcomes of recovery(13).Few studies have looked at hand strength predictors themselves. Sex, age, body height and mid-forearm circumference are good predictors. Body weight and hand size measurements are poorer predictors. Grip strength has often been taken as a proxy for overall strength, but this should be done with caution because in many, but also in few environments, the association of the two strength measures is high (1).

V. Conclusion:

hand grip strength had correlation with both BMD and hand function and could be used as a predictor for bone density and hand skill in preschool children.

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