Relationship between muscular fitness and bone health in young baseball players

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Abstract

The physical actions developed by baseball players can increase muscular fitness, and consequently improve bone health. The objective was to relate some indicators of muscular fitness to bone health in young baseball players. A descriptive cross-sectional study was carried out in 102 children and adolescent baseball players of the Brazilian National Team. The age range ranged from 9.0 to 15.0 years, the average chronological age was 12.2±2.2 years and the maturity status was 14.8±0.5 APHV (age at peak height velocity). Anthropometry, body composition [% fat, fat mass (FM) and fat-free mass (FFM)], physical tests [horizontal jump (HJ) and medicine ball throw (MBT)] bone health was estimated by anthropometry [bone mineral density (BMD) and bone mineral content (BMC)]. There was positive and significant correlation between bone health with FFM (r2= 89%) and with muscle strength tests (HJ and MBT) (R2= 55 to 75%). Young baseball players classified with low bone health level, reflected decreased values of FFM, HJ and MBT, in relation to young players classified with moderate and high bone health level ($p<0.05$). It was shown that good bone health is a consequence of a greater presence of muscular fitness, as a result of increased physical activity. These results suggest that emphasis should be placed on those young people who present a greater risk of having low BMD and BMC.

Key Words: muscle fitness; bone health; baseball; youth.

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Baseball is a sport played in different parts of the world.Iit is widely practiced in America, Europe and Japan,[1] and is very popular in some Central American countries, where it is one of the most popular sports.[2] This sport is characterized by presenting great offensive and defensive aspects that require various levels of strength, power, agility, balance, coordination, displacement speed, arm and leg speed, local muscular endurance and cardiorespiratory capacity.[3,4] Physical performance in sports science is considered extremely important to improve competitive performance, although the acquisition of game-specific skills,[5-7] as well as body composition, biological maturation and bone health during the growth period are fundamental factors that should be permanently monitored in young athletes and non-athletes.[8,9] In fact, muscle and bone health (as a product of musculoskeletal activity) is evidenced in the expression of strength, muscular endurance and quality of life in various activities of daily living and in specific physical-sports and recreational activities.[10] In that sense, muscle and bone are inextricably linked not only mechanically but also genetically and molecularly,[11] so this process is controlled by complex and selective genetic and environmental factors, which include hormone status, sex, nutrition, physical activity, alcohol consumption that may influence bone growth during early life.[12,13] "Muscular fitness" has been used to represent muscular strenght, local muscular endurance and muscular power.[14] Indeed, it is the main component in adolescence that correlates broadly with adult bone mineral content (BMC).[15] So there is strong evidence that strength training activities (i.e., high muscle load activity such as weight lifting) produce a significant increase in BMC,[15] while running or cross-country skiing produce positive effects on bone mineral density (BMD).[16]

Because many sports impose relatively large unilateral loads, child and adolescent baseball players are expected to reflect positive relationships between indicators of muscle fitness with bone health, in this study it is expected that the physical actions developed in baseball players may increase muscle fitness, because actions that generate tension and compression forces stimulate the bone remodeling process increasing BMD and explosive strength.[17-19]

Materials and Methods

A cross-sectional descriptive study was carried out in 102 male children and adolescent baseball players. The sample was selected by convenience (non-probabilistic). All those evaluated belonged to four Brazilian state teams, which represented Brazil in international competitions in grassroots categories during the period 2017 and 2018. The age range was from 9.0 to 15.0 years. The average chronological age was 12.2±2.2 years and the maturity status was 14.8±0.5 APHV (age at peak height velocity). All baseball players who had a minimum of 2 years of systematic practice in the modality and those who attended scheduled evaluations were included in the study. Those who were outside the age range and those who presented some type of sports injury that prevented anthropometric and physical performance evaluation were excluded. Before being evaluated, the subjects were informed and completed an assent form. The parents signed the authorization as suggested by the Ethics Committee of the State University of Campinas, Brazil (no. 2.457.445). All evaluations were conducted at the training facilities of the Brazilian Baseball and Softball Confederation (Sao Paulo, Brazil). The evaluations were organized by stations: Anthropometry and physical performance tests. Previously, the clubs informed the dates of birth and the time of practice in the modality of each of the baseball players. This information was transferred to an individual evaluation form. The anthropometric evaluation was carried out according to the suggestions described by Ross, Marfell-Jones.[20] All variables were evaluated twice and skinfolds, femur diameter and forearm length were performed on the right side of the body. The technical error of ETM measurement of the variables ranged from 1 to 3%. The procedure was performed by a single evaluator. Standing height was measured using a portable stadiometer (Seca Gmbh & Co. KG, Hamburg, Germany) with an accuracy of 0.1 mm, sitting height was measured

Table 1. *Characterization of the sample studied.*

Variables	X	SD	Lower limit	Upper limit
Age (years)	12,21	1,69	11,88	12,54
Maturity stage (APHV)	14,80	0,47	14,57	15,02
Anthropometry				
Weight (kg)	51,44	15,09	48,47	54,40
Height (cm)	155,08	12,84	152,55	157,60
Sitting height (cm)	79,60	6,51	78,32	80,87
BMI (kg/m^2)	20,93	3,51	20,24	21,62
Body composition				
Fat percentage (%F)	20,28	6,21	19,06	21,50
Fat Mass (kg)	10,79	5,52	9,71	11,88
Fat Free Mass (kg)	40,64	11,15	38,45	42,83
Muscle fitness				
HJ (cm)	184,66	29,76	178,81	190,50
MBT (cm)	658,14	202,79	618,31	697,97
Bone Health				
BMD (g/cm^2)	0,89	0,11	0,87	0,92
BMC (g)	1,93	0,16	1,90	1,96

Legend: *X: Average, SD: Standard deviation, APHV: age of peak height velocity, BMI: Body Mass Index, HJ: Horizontal jump, MBT: Medicine ball throw, BMD: Bone mineral density BMC: Bone mineral content.*

while the subject was seated on a wooden bench with a height of 50 cm, and a wall-mounted stadiometer with an accuracy of 1 mm. Skinfolds (tricipital and subscapular) were measured with a skinfold adipometer (Harpenden, England). Forearm length (cm) was assessed between the radial and bi-styloid point, using a Cescorf brand anthropometer (Made in Brazil) with a scale from 0 to 60 cm with an accuracy of 1 mm. The diameter of the biepicondylar femur (cm) was evaluated using a Cescorf anthropometer (Made in Brazil) with a scale of 0 to 20 cm and an accuracy of 1 mm. The percentage of fat (%F) was calculated using the equation proposed by Boileau et al.[21] using the tricipital and subscapular folds. Fat mass (FM) and fat-free mass (FFM) were derived using total body weight. Somatic maturity status was determined using the equation proposed by Mirwald et al.[22] adjusted for age and sex. This technique allows interpretation of the time before or after reaching maximum stature velocity, expressed in APHV. Bone health, both BMD and BMC were calculated by means of the anthropometric equations proposed by Gómez-Campos et al.,[23] adjusted for age and sex. These are based on the use of femur diameter (cm), forearm length (cm) and APHV. These equations were validated using dual-energy X-ray absorptiometry (criterion method) and were proposed as a non-invasive alternative for estimating bone health. Bone health categories were considered, according to BMD percentile (P) values: <P25: low BMD, P25-P75: medium BMD and >P75: high BMD.

The physical performance tests were evaluated after warm-up and flexibility exercises (10-15 minutes). The tests were evaluated in the following order: Horizontal Jump (HJ) and Medicine Ball Throw (MBT). All this procedure was performed by an experienced evaluator. All tests were evaluated twice. The ETM ranged in the tests from 1.5 to 2.5%. Horizontal jump (cm) was evaluated on the gras. A 3m tape measure with an accuracy of 1mm was used, following the recommendations of Castro-Piñero et al.[24] The MBT (m) was evaluated over the gras from the standing position and above the head. A 20m tape measure with an accuracy of 1mm and a 2kg ball were used, following the recommendations of Legido et al.[25] Normal distribution of the data was verified by using the Shapiro-Wilk test (for age). Descriptive statistics of mean, standard deviation and range were calculated. Differences between bone health categories were determined by one-way Anova and Tukey's test of specificity. Relationships between variables were verified by Pearson's test and % explanation was determined by adjusted R^2. In all cases, $p<0.05$ was adopted. Calculations were performed in Excel spreadsheets and Sigma Stat 8.0.

Results

The anthropometric variables, body composition, muscle fitness tests and bone health indicators are shown in Table 1. The mean chronological age was 12.21±1.69years and maturity status was verified at 14.80±0.47APHV. Comparisons of muscle fitness (HJ and MBT) and body composition (FFM) indicators, aligned according to bone health categories are presented in Table 2. There were significant differences in the two muscle fitness indicators and FFM. Young baseball players classified with low BMD and BMC evidenced significant differences with those classified in the medium and high categories ($p<0.05$). There were no significant differences between the medium and high categories ($p>0.05$). The bivariate relationships and explanatory power between bone health (BMD and BMC) with muscle fitness indicators are shown in Figure 1. It is highlighted that the highest explanatory power was observed between BMD and BMC with the FFM (R^2= 89%) and slightly lower with the HJ and MBT tests (R^2= 55 to 75%), respectively.

Discussion

This study shows that there is a positive and significant relationship between indicators of muscular fitness and bone health in young baseball players. Several studies have previously evidenced these relationships in other sports modalities such as judo, karate, tennis, basketball, soccer.[26-30] There is now strong empirical evidence that physical exercise affects normal muscle and bone development,[31,32] specifically muscular resistance training is important to improve strength, increase lean mass (regional and body) and prevent risk factors that may compromise the mineral integrity of bone tissue, in any age group and of both sexes.[33] Young baseball players classified with low bone density and bone

Table 2. *Comparison of muscle fitness indicators and FFM according to bone health categories.*

Indicators	Low (n=7)		Medium (n=54)		High (n=41)	
	X	SD	X	SD	X	SD
FFM (kg)	29,83	2,38	39,20	5,30[a]	43,54	12,43[a]
HJ (cm)	170,57	10,23	185,01	15,90[a]	186,39	13,97[a]
MBT (cm)	500,00	33,17	660.09	122,78[a]	715,49	235,92[a]

Legend: X: Average, SD: Standard deviation, FFM: Fat Free Mass, HJ: Horizontal jump, MBT: Medicine ball throw. a: significant difference in relation to the low BMD category

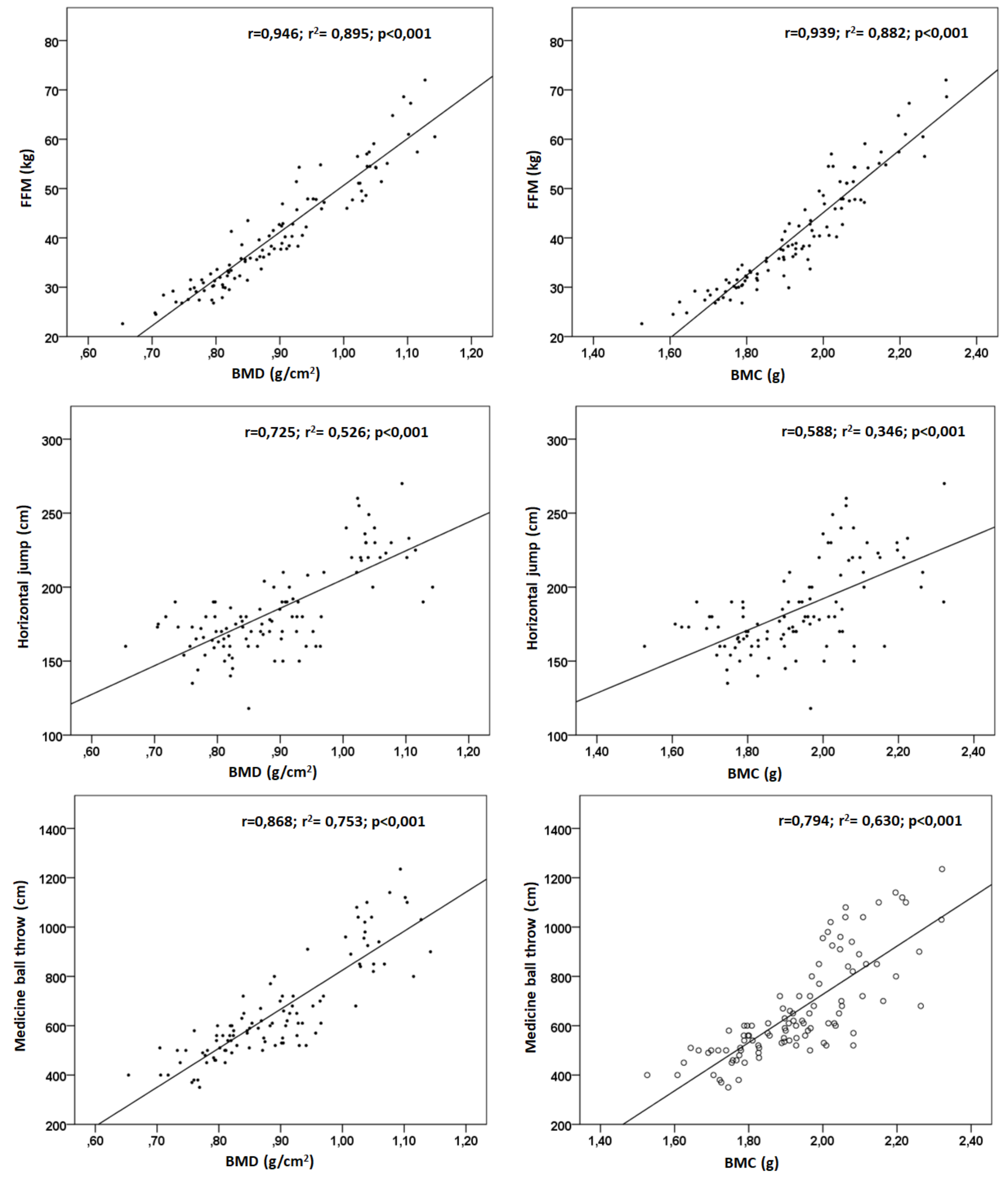

Fig 1. *Relationship between muscle fitness indicators with BMD and BMC in young baseball players.*

mineral content reflected lower values in muscle fitness indicators relative to those classified with moderate and high bone health. This is evidence of decreased muscle fitness performance relative to their counterparts with better bone health. During the first two decades of life, the skeleton grows in both size and density, and it is estimated that more than half of the peak bone mass is acquired during adolescence.[34] Therefore, the loss of bone mass and structural properties of bone during growth stage must be treated in time, otherwise it leads to bone fragility and the risk of fracture in the future,[35] the risk of sports injuries included.[36] Consequently, adolescence and early adulthood are the most beneficial times for long-term bone density gains, with nearly 90% of peak bone mass gained by age 18 years,[37] so dosing of training loads should be evaluated and monitored periodically during the stage of biological growth and maturation. Dynamic sports with short, high and

multidimensional loads are those that produce the strongest effects on bone formation, regardless of the amount of training,[26] therefore, it is necessary to constantly evaluate bone health in children and adolescents, not only baseball players, but also in other sports and the general population. Bone is a main component of body and its health status is very important for prevention of osteoporosis.[38] To optimize bone health by proper nutrition, appropriate weight-bearing exercise, strength training, and adequate calcium and vitamin D intake is needed throughout life.[34] Considering the importance of individual and collective bone health assessment in young baseball players, non-invasive methods, as are the regression equations predicting BMD and BMC proposed by Gomez-Campos et al.,[23] are useful alternatives that may be applied constantly in young baseball players before, during and after the sport seasons. In addition, athletes and coaches should focus on developing and maintaining strength indicators, because they seem to be the best indicators of athletic performance at least in young baseball players.[39]
This study has some weaknesses: i) it was not possible to evaluate dietary habits and calcium intake, and ii) it was not possible to have a control group. Notwithstanding, this is a first study carried out in selected young Brazilian baseball players that may serve as a baseline for future studies. In conclusion, it is necessary to maintain high levels of performance in indicators of muscular aptitude to maintain moderate and high levels of bone health, the results suggesting to place attention to young people presenting greater risks of low BMD and BMC. Anyhow, further studies are needed to confirm these conclusions.

Authors contributions

MCB, RGC, MA: conception, design, drafting of the manuscript, analysis and interpretation of all data, critical review and final approval of the version to be published, agreement to be responsible for all aspects of the work to ensure that issues related to the accuracy or completeness of any part of the work are adequately investigated and resolved; MCB, RGC, RVE, MA, LUA, JST: critical review of important intellectual content; and final approval of the version to be published; JMB, MA: acquisition of data, analysis and interpretation of the data, critical review and final approval of the version to be published.

Acronyms

APHV - age at peak height velocity
BMC - Bone mineral content
BMD - bone mineral density
BMI - Body Mass Index,
FM - Fat mass
FFM - Fat Free Mass
HJ - Horizontal jump
MBT - Medicine ball throw.
SD - Standard deviation
X: - Average

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Conflict of Interest

The authors declare no conflicts of interests

Ethical Publication Statement

We confirm that we have read the Journal's position on issues involved in ethical publication and affirm that this report is consistent with those guidelines.

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