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CORRELATION OF HAND MEASUREMENTS, ENERGY AND MACRO-NUTRIENT INTAKE WITH HAND GRIP STRENGTH IN ADOLESCENT BASKETBALL PLAYERS

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ABSTRACT

Hand grip strength is a fundamental attribute of athletic performance, particularly in sports requiring significant upper body strength and manual dexterity, such as basketball. In adolescent athletes, identifying factors that influence hand grip strength is crucial for optimizing training and nutrition strategies. This study investigates the relationship between hand dimensions, energy and protein intake, and hand grip strength in adolescent basketball players. The sample comprised 400 regular practicing basketballers (girls & boys) of age group 10 to 15 years from different clubs of Nagpur, Maharashtra, India. Hand dimensions, including arm length, arm span, hand span, palm width and length, index and ring finger lengths, mid upper arm circumference, forearm circumference and wrist circumference were measured using standard anthropometric techniques. Dietary intake was assessed through a 3-day food diary, and hand grip strength was evaluated using a digital dynamometer. Results indicated significant correlations between hand dimensions and hand grip strength, with larger hand spans and longer finger lengths associated with higher grip strength ($p<0.01$). Additionally, dietary analysis revealed that higher energy and macronutrient intakes were positively correlated with hand grip strength ($p<0.01$). These findings suggest that hand dimensions and adequate nutritional intake, particularly energy and protein, play essential roles in enhancing haand grip strength in adolescent basketball players. The study highlights the importance of considering both physical attributes and dietary factors in training programs to optimize performance. This research provides practical recommendations for coaches and nutritionists to develop targeted interventions aimed at improving the grip strength and overall athletic performance of young basketball players.

Keywords: *Hand anthropometry, hand grip strength, dynamometer, food diary*

INTRODUCTION:

Basketball is a sport that demands a high level of physical fitness, technical skill, and tactical intelligence. Among the various physical attributes that contribute to a player's performance, hand strength and dexterity are particularly crucial. Hand grip strength, in particular, is an essential component for effective ball handling, shooting accuracy, and defensive maneuvers. Understanding the factors that influence hand grip strength can provide valuable insights for optimizing training and improving performance in young athletes.

Hand anthropometry, the measurement of the dimensions of the hand, has been identified as a potential determinant of grip strength. Variables such as hand length, palm width, finger length, and overall hand size may influence an individual's ability to generate grip force. In the context of adolescent basketball players, whose bodies are still developing, understanding the relationship between these anthropometric variables and grip strength is especially important. This knowledge can inform coaches and trainers in tailoring training programs that enhance grip strength, thereby potentially improving overall basketball performance.

Adolescence is characterized by rapid growth and development, during which nutritional intake and physical attributes undergo substantial changes. Proper nutrition, especially adequate energy and protein intake, is essential for supporting this growth and enhancing physical performance. Protein is critical for muscle repair and growth, while sufficient energy intake ensures that athletes meet their heightened metabolic demands (American College of Sports Medicine, 2016). Previous studies have shown that inadequate nutrition can impair physical performance and increase injury risk (Beck et al., 2015).

Hand dimensions, including hand span and finger length, are physical attributes that may influence hand grip strength. Larger hand dimensions can provide a mechanical advantage in grip-related activities, potentially enhancing performance in sports such as basketball (Visnapuu and Jurimae, 2007). The relationship between hand dimensions and grip strength has been documented in various populations, but specific data on adolescent basketball players are limited (Koley et al., 2009; Prista et al., 2003).

Furthermore, hand grip strength is a reliable indicator of overall muscular strength and has been associated with athletic performance in youth sports (Lopez-Bueno et al., 2020). Investigating the interplay between hand dimensions, dietary intake, and grip strength in adolescent basketball players can provide valuable insights for developing effective training and nutritional interventions.

Previous research has explored the relationship between hand dimensions and grip strength in various populations, including adults and different athletic cohorts. For instance, studies have shown significant correlations between hand size and grip strength in both general and athletic populations (Kamarul et al., 2006; Pheasant, 1996). However, there is a paucity of studies focusing specifically on adolescent basketball players, a group that undergoes rapid physical and physiological changes. This study aims to fill this gap by examining the correlation between hand anthropometric measurements and grip strength in this specific population. By identifying key anthropometric predictors of grip strength, this research seeks to contribute to the development of targeted training interventions that can enhance performance and reduce injury risk in young basketball players.

The objectives of this study are threefold: first, to measure the hand dimensions and grip strength of adolescent basketball players; second, to explore how hand dimensions correlate with hand grip strength and how dietary factors, such as energy and protein intake, modulate this relationship. By providing a comprehensive analysis, this research aims to provide a comprehensive understanding of how hand anthropometry and energy and macro-nutrient intake influence grip strength.

METHODOLOGY:

The present study deals with the assessment of hand dimensions, dietary intake with respect to energy, carbohydrates, protein and fat and hand grip strength of girls and boys engaged in regular basketball training.

Sample population and size:

Total 400 regular practicing basketballers (girls and boys) of age group 10 to 15 years were chosen from leading basketball clubs from Nagpur city, Maharashtra, India. 100 girls and 100 boys from each age group of 10 to 12 years and 13 to 15 years) were purposively selected.

Hand measurements:

Hand measurements like arm length, arm span, hand span, palm width, palm length, index finger length, ring finger length, mid upper arm circumference, forearm circumference and wrist circumference of players were measured using non-stretchable plastic tape.

Nutrient intake:

Precise information on dietary intake of subjects was gathered through 24 hour's dietary recall method for three consecutive days (three day's dietary recall). This was done to collect very accurate information about the quantity of foods consumed by the basketballers. The data about food intake from their first meal of the after arising in the morning till the last meal consumed before bed time was collected. Information about inclusion of type and quantity of cereals, millets, pulses, legumes, vegetables (roots, tubers, green leafy and other), fruits, milk and its products, nuts, oil seeds, dry fruits, fats and oils, sugars, eggs, non-vegetarian foods (meat, chicken, fish, sea foods etc). Based on 24 hour's dietary recall method for consecutive three days, nutritive values of diets consumed by the players were computed using the food composition tables given by Gopalan, C. et al. (2012) and Longvah, T. et al. (2017). Energy and macro-nutrients were calculated. Actual nutrient intake values of basketball players were compared with recommended dietary allowances (RDAs) (National Institute of Nutrition (NIN)/Indian Council of Medical Research (ICMR), 2009).

Hand grip strength:

A digital hand dynamometer was used to perform the hand-grip test. To perform the test, the basketballer was asked to hold the dynamometer in the right hand with the arm at right angles and the elbow by the side of the body. The handle of the dynamometer was adjusted when required - the base resting on first metacarpal (heel of palm), while the handle resting on middle of four fingers. The player was asked to squeeze the dynamometer with maximum effort, which was maintained for about 5 seconds. No other body movement was allowed. The subjects were strongly encouraged to give a maximum effort (http://www.topendsports.com/testing/ tests/handgrip.htm). The best result from three trials for dominant hand was recorded, with at least 15 seconds recovery between each effort. Normative data is not available for hand grip strength test for 10-13 yrs old children. But

normative data is available for age group 13-16 yrs, based on which normative data for 10-13 yrs age group was derived. Normative data for hand grip strength test presented in Table 1 is used for comparisons between the actual results of hand grip strength test of basketballers with the standard reference norms.

Table 1: Normative Data for Hand Grip Strength Test

Age Groups (Yrs)	Excellent	Good	Average	Fair	Poor
Females (Reading in kg)					
10-12*	>25	22-25	18-21	13-17	< 13
13-15	>32	27-32	22-26	17-21	< 17
Males (Reading in kg)					
10-12*	>39	35-39	31-34	27-30	< 27
13-15	>49	45-49	40-44	34-39	< 34

* Derived Normative Data for Hand Grip Strength Test

Source: Davis, B. et al. (2000) and Nande, P. J. & Vali, S. A. (2010).

Statistical analysis:

Obtained data for basketballers were compared with the standards and recommended dietary allowances (RDAs). Percentage excess or deficit was calculated. Between and within group comparisons were done.

Mean & standard deviation were drawn for male and female basketballers from age groups- 10-12 yrs and 13-15 yrs.

Minimum & maximum values were drawn for both the age groups of girls and boys i.e. 10-12 and 13-15 yrs.

Percentages were calculated for various parameters for female and male basketballers from age groups 10-12 yrs and 13-15 yrs.

z test: For females and males (for each age group) comparison between data and standards/RDAs was done using one sample z test. This large sample test (independent samples test) was used to assess the significance of the difference between sample mean and standard/RDA. Comparisons were done for hand measurements, nutrient intake and hand grip strength physical fitness parameters.

Two sample z test was used for within gender group comparisons. Female basketballers from age group 10-12 yrs were compared with those from age group 13-15 yrs whereas male basketballers from age group 10-12 yrs were compared with those from age group 13-15 yrs. This was done to see effect of age on various parameters.

To assess effect of gender on hand grip strength, between gender comparisons were done using two sample z test. For this, female basketballers from age group 10-12 yrs were compared with male basketballers from age group 10-12 yrs. Similarly, female basketballers from age group 13-15 yrs were compared with male basketballers from age group 13-15 yrs.

Critical value of z was tested at both 0.01 and 0.05 levels of significance (1.96 and 2.58, respectively).

Pearson's coefficient of correlation test: Pearson's product moment coefficient of correlation method was used to derive relationship between various parameters for each age group of female and male basketballers. Within group strength of relationship between

various measures was assessed. A level of significance at both 5% (0.05) and 1% (0.01) levels was assumed to draw conclusions.

RESULTS AND DISCUSSION:

Hand measurements:

Table 2 shows the data on mean, standard deviation, range and z values of arm length, arm span and hand span of basketballers.

Table 2: Data on Hand Lengths and Widths of Basketballers

Sr. No.	Parameters	GIRLS			BOYS		
		Age Group 10-12 Yrs (n=100)	Age Group 13-15 Yrs (n=100)	z Values¶	Age Group 10-12 Yrs (n=100)	Age Group 13-15 Yrs (n=100)	z Values¶
1	**Arm Length (cm)**						
i	**M±SD**	56.30±5.21	61.84±5.39		54.61±5.01	64.08±7.79	
ii	**Range**	45.50-66.00	46.00-72.00		44.50-69.00	49.00-87.00	
iii	**Standard**	63.67	67.72	**7.39***	60.31	68.27	**10.23***
iv	**% Deficit**	-11.58	-8.68		-9.45	-6.14	
v	**z Values#**	**14.16***	**10.93***		**11.38***	**5.38***	
2	**Arm Span (cm)**						
i	**M±SD**	141.00±8.85	152.87±7.72		138.31±9.73	155.20±12.5	
ii	**Range**	120.00-159.00	132.50-169.00	**10.09***	119.00-167.00	125.00-190.00	**10.67***
iii	**Standard**	148.67	159.48		149.14	168.38	
iv	**% Deficit**	-5.15	-4.14		-7.25	-7.83	
v	**z Values#**	**8.65***	**8.57***		**11.14***	**10.55***	
3	**Hand Span (cm)**						
i	**M±SD**	18.36±1.60	19.26±1.18		18.09±1.31	20.12±1.76	
ii	**Range**	15.50-27.00	16.00-22.00		15.00-21.50	17.20-27.00	
iii	**Standard**	17.25	18.49	**4.57***	17.6	20.04	**9.30***
iv	**%Excess**	+6.43	+4.16		+2.78	+0.40	
v	**z Values#**	**6.92***	**6.54***		**3.71***	**0.47**	
4	**Palm Width (cm)**						
i	**M±SD**	7.40±0.50	7.68±0.50	**3.96***	7.52±0.80	8.13±0.72	
ii	**Range**	6.00-8.50	6.00-9.00		6.50-11.50	6.30-11.5	
iii	**Standard**	6.90	7.60		7.07	7.50	**5.72***
iv	**% Excess**	+7.25	+1.05		+6.36	+8.40	
v	**z Values#**	**9.89***	**1.55**		**5.53***	**8.80***	
5	**Palm Length (cm)**						
i	**M±SD**	16.46±1.00	17.34±0.93	**6.41***	16.07±1.13	17.75±1.40	
ii	**Range**	14.00-19.00	13.50-19.70		14.00-19.50	15.50-22.00	**9.32***
iii	**Standard**	15.20	16.80		15.27	15.90	
iv	**% Excess**	+8.29	+3.21		+5.24	+11.64	

v	**z Values#**	**12.65***	**5.77***		**7.14***	**13.19***	
6	**Index Finger Length (cm)**						
i	**M±SD**	6.30±0.56	6.76±0.56	**5.71***	6.03±0.59	6.85±0.70	**8.85***
ii	**Range**	3.20-7.90	5.40-8.10		5.00-8.50	5.40-9.00	
iii	**Standard**	6.20	6.80		6.07	6.87	
iv	**% Deficit**	+1.61	-0.59		-0.66	-0.29	
v	**z Values#**	**1.79**	**0.80**		**0.61**	**0.31**	
7	**Ring Finger Length (cm)**						
i	**M±SD**	6.86±0.50	7.11±0.53	**3.47***	6.63±0.55	7.36±0.70	**8.14***
ii	**Range**	5.90-8.20	5.00-8.50		5.60-8.40	6.10-9.50	

¶ - z values are for between group comparison (i.e. comparison between age groups 10-12 yrs & 13-15 yrs); # - z values are for comparison between data of subjects & standards; * - Significant at both 5 % & 1% levels ($p<0.01$); ** - Significant at 5 % level but insignificant at 1 % level ($0.01<p<0.05$); Values without any mark indicate insignificant difference at both 5% & 1% levels ($p>0.05$).

Arm length is one of the factors contributing to an athlete´s success. Some of the advantages of long arms for sports like basketball are obvious -- longer arms make it easier to reach the ball, and therefore to catch it. Longer arms can also help throw a ball faster and farther due to the increased centrifugal force basketballers can generate during the throwing motion (https://howtheyplay.com/misc/The-Advantages-of-Long-Arms-in-Sports). Arm span measurement is a simple measure that is important in the anthropometrical profiling of athletes in many sports in which reach is important, such as basketball. Long arms are advantageous for some sports which involve reaching and tackling (https://www. topendsports.com/testing/tests/arm-span.htm). Chisi, J. & Zverev, Y. (2005) & Engstrom, F. M. et al. (1981) stated that measuring the arm span is crucial in the evaluation of body proportions. Hand span is a measure of distance from the tip of the thumb to the tip of the little finger with the hand fully extended. The size of the hand makes a difference in basketball that involves throwing, gripping or catching (https://www.wikihow.com/Measure-Hand-Size).

Mean values for girls aged 10-12 yrs, girls aged 13-15 yrs, boys aged 10-12 yrs & boys aged 13-15 yrs were noted as 56.30±5.21 cm, 61.84±5.39 cm, 54.61±5.01 cm and 64.08±7.79 cm for arm length; 141.00±8.85 cm, 152.87±7.72 cm, 138.31±9.73 cm and 155.20±12.5 for arm span and 18.36±1.60 cm, 19.26±1.18 cm, 18.09±1.31 cm and 20.12±1.76 cm for hand span, respectively (Table 2). Elder female & male players under this study possessed higher mean values for arm length, arm span and hand span. It is postulated that that tall people tend to have longer arms. When statistical comparisons were done using ‘z’ test, it was seen that older female players had significantly longer mean arm length, arm span & hand span than younger female players ($z=7.39$, 10.09 & 4.57, respectively, $p<0.01$). Similarly, older male players had significantly longer mean arm length, arm span & hand span than younger male players ($z=10.23$, 10.67 & 9.30, respectively, $p<0.01$.

Pizzigalli, L. et al. (2017) studied anthropometric characteristics in Italian female national basketball teams (under 14 to senior) and found no statistically significant

differences for hand span among all elite level groups, but seniors showed higher values than younger groups (under-14 and under-15) for arm length ($p<0.05$).

For the present study, in comparison with standards, players possessed significantly shorter mean arm length & arm span ($p<0.01$). The deficits were derived as 11.58%, 8.68%, 9.45% & 6.14% for arm length for girls from age groups 10-12 yrs and 13-15 yrs and boys from age groups 10-12 yrs and 13-15 yrs, respectively ($z=14.16$, 10.93, 11.38 & 5.38, respectively) and 5.15%, 4.14%, 7.25% & 7.83% for arm span for girls from age groups 10-12 yrs and 13-15 yrs and boys from age groups 10-12 yrs and 13-15 yrs, respectively ($z=8.65$, 8.57, 11.14 & 10.55, respectively). In contrast to the results of arm length & arm span, girls & boys from age groups 10-12 yrs and 13-15 yrs had wider hand span in comparison with reference standards. The results were statistically significant for younger & older girls & younger boys ($z=6.92$, 6.54 & 3.71, respectively, $p<0.01$) but insignificant for older boys ($z=0.47$, $p>0.05$). Hand span was found to be affected by age, older groups of female & male basketballers showed significantly longer hand span than younger groups of female & male basketballers ($z=4.57$ for girls aged 10-12 yrs vs. girls aged 13-15 yrs and $z=9.30$ for boys aged 10-12 yrs vs. boys aged 13-15 yrs).

Ball games require comprehensive ability including physical, technical, mental and tactical abilities. Among them physical abilities of players exert marked effects on the skills of the players themselves and the tactics of the team. For the ball games in which the use of the hand is essential, hand morphology and functional properties are very important for the performance (Barut, C. et al., 2008).

From Table 2, it is noted that mean values of palm width of basketballers were recorded as 7.40±0.50 cm, 7.68±0.50 cm, 7.52±0.80 cm and 8.13±0.72 cm for girls aged 10-12 yrs, girls aged 13-15 yrs, boys aged 10-12 yrs & boys aged 13-15 yrs, respectively whereas mean palm length values were found as 16.46±1.00 cm, 7.34±0.93 cm, 16.07±1.13 cm and 17.75±1.40 cm for girls aged 10-12 yrs, girls aged 13-15 yrs, boys aged 10-12 yrs & boys aged 13-15 yrs, respectively. Wider differences were noted in both the width & length readings of palms as also seen from the minimum & maximum values which were 6.00-8.50 cm, 6.00-9.00 cm, 6.50-11.50 cm and 6.30-11.5 cm for palm width and 14.00-19.00 cm, 13.50-19.70 cm, 14.00-19.50 cm and 15.50-22.00 cm (Table 2) for palm length for girls aged 10-12 yrs, girls aged 13-15 yrs, boys aged 10-12 yrs & boys aged 13-15 yrs, respectively.

Bigger hand surfaces give the ability to easily palm the ball and make the basket. From Table 2, it can be observed that girls & boys from age groups 10-12 yrs & 13-15 yrs possessed wider & longer palms as compared to reference standards [$z=9.89$ & 12.65 for girls aged 10-12 yrs ($p<0.01$); $z=1.55$ ($p>0.05$) & 5.77 ($p<0.01$) for girls aged 13-15 yrs; $z=5.53$ & 7.14 for boys aged 10-12 yrs ($p<0.01$) and $z=8.80$ & 13.19 for boys aged 13-15 yrs ($p<0.01$), respectively for palm width & palm length].

Hand size affects passing, shooting, and ball handling. Players with small hands might find themselves losing control of the ball more while dribbling or passing. Upper extremity muscle and grip strength are the primary physical factors affecting passing accuracy. Moreover, all shots and passes work more efficiently when the hand surface parameters are larger and when the fingers are longer and stronger (which probably yields better handgrip strength) (Jurimae, T. and Visnapuu, M., 2007 & Fallahi, A. A. and Jadidian, A. A., 2011).

The data from Table 2 showed significant differences for both the genders when compared between the younger and older groups for mean palm width ($z=3.96$ for girls and 5.72 for boys, $p<0.01$) and palm length ($z=6.41$ for girls and 9.32 for boys, $p<0.01$). The difference was found more pronounced in male players than female players. This might be attributed to gender specific effect along with positive effect of sports training.

In a study carried out by Tsakalou, L. et al. (2015), the 12 year old girls were in cardinal numbers and heavier than the boys but showed a shorter palm length. After the age of 13 years, the boys outmatch the girls significantly in hand the span and the length of the palm. According to Zapartidis, I. et al. (2011), the greatest differences, considering sex, regarding the ball throw velocity; seem to appear near the ages of 12-13 years old, with boys increasing significantly their performance in relation to girls after the age of 14 years old. Pizzigalli, L. et al. (2017) studied Italian female national basketballers & found that they had the mean hand length measures exceeding by 95^0 percentile which was found to be more than non-athlete Italian adult females. Scheuer, L. et al. (2009) & Rowland, T. W. (1996) reported that muscolo-skeletal improvement is completed in females around 19 years for muscle mass, while this already took place at around 14 years for hand bones but only around 20 years for arm bones. Barut, C. et al. (2008) compared hand anthropometric measurements and grip strength among different sports groups aged between 9-18 years and concluded that there were statistically significant differences for hand width, finger index, hand length/height, hand length/height values between basketball, handball and volleyball players.

Handgrip strength is important for catching and throwing the ball in different team sports. When the fingers are longer and hand surface variables greater than required for grasping an object (ball), fingers less widely spread, and grasping an object becomes more efficient and less fatiguing (Nag, A. et al., 2003). Fingers are the smallest, lightest parts of the motor apparatus, and, therefore, they represent the parts most easily deflected by force from the ball, but at the same time, finger control is especially important for the accuracy of different shots in basketball. Thus, it is especially necessary to measure finger length and perimeters of the hand for practical reasons (Jurimae, T. and Visnapuu, M., 2007).

Studies on index finger length and ring finger length of basketballers especially from age group of 10-15 yrs are not done widely. Mean values for index finger length were noted as 6.30±0.56 cm, 6.76±0.56 cm, 6.03±0.59 cm and 6.85±0.70 cm, whereas mean values for ring finger length were noted as 6.86±0.50 cm, 7.11±0.53 cm, 6.63±0.55 cm and 7.36±0.70 cm (Table 2) for girls from 10-12 yrs, 13-15 yrs and boys from 10-12 yrs, 13-15 yrs, respectively. Girls from age group 10-12 yrs had longer mean index finger and ring finger lengths than boys from same age group. In contrast to this, boys from age group 13-15 yrs had longer mean index finger and ring finger lengths than girls from same age group. Very high variability was noted among players for the upper and lower values recorded for these measurements. The highest value for index and ring finger lengths were recorded as 9.00 cm & 9.50 cm, respectively. It was very interesting to note that the highest value for ring finger length was greater than the highest value of index finger length which may be attributed to genetic makeup. The lowest values were recorded as 5.00 cm for both for index and ring finger lengths (Table 2). The z values indicated insignificance of differences for all the groups of players for comparisons of mean index finger lengths with standards ($z=0.31$ to 1.79, $p>0.05$). With the exception of younger girl's group, the subjects from other groups

failed to match the respective standards for index finger length having % deficit values calculated as 0.59, 0.66 and 0.29 for girls from age group 13-15 yrs and boys from age groups 10-12 yrs, 13-15 yrs, respectively

Beunen, G. and Malina, R. M. (1988) stated that during adolescence, the development rate of the boys is double to the girls' for the upper limbs and only slightly larger for the lower limbs. For this study, within gender, age wise comparisons for index finger length and ring finger length revealed that older female and male basketballers showed significantly greater mean values than younger female and male basketballers & the differences were significant at both 5% & 1% levels (z=5.71 & 8.85, respectively for index finger length and z=3.47 and 8.14 respectively for ring finger length in girls and boys aged 10-12 yrs & 13-15 yrs, respectively).

Nag, A. et al. (2003) studied hand anthropometry of Indian women and concluded that handgrip strength is important for catching and throwing the ball in different team sports and when the fingers are longer, hand surface variables are greater for grasping an object (ball) & hence, fingers are less widely spread, and grasping an object becomes more efficient and less fatiguing. Similarly, Jurimae, T. and Visnapuu, M. (2007) also stated that in grip sports, like basketball, the longer the fingers, the better is the accuracy of the shot or throw. All shots and throws are finished with the wrist and fingers and they also proposed that athletes with longer fingers and greater hand surface also have greater grip. Fallahi, A. A. and Jadidian, A. A. (2011) studied the effect of hand dimensions, hand shape and some anthropometric characteristics on handgrip strength in male grip athletes and non-athletes and found no significant difference between the groups in finger spans, but there was a significant difference in index finger length ($p<0.001$) and ring finger length ($p<0.001$) between the groups. They also concluded that finger lengths may be more significant in handgrip strength than palm length and especially index finger length in athletes may be good predictors of handgrip strength. Jurimae, T. and Visnapuu, M. (2007) studied the influence of general body and hand-specific anthropometric dimensions on handgrip strength in 193 boys aged 10-17 yrs, participating in basketball training and observed that the effect of finger length and finger variables on handgrip strength was more than that of finger spans so that finger spans had a small influence on handgrip strength. In a study by Fallahi, A. A. and Jadidian, A. A. (2011), all finger lengths and perimeters of the hand were significantly different ($p<0.001$) between male grip athletes and non-athletes.

Table 3: Data on Hand Circumferences of Basketballers

Sr. No.	Parameters	GIRLS			BOYS		
		Age Group 10-12 Yrs (n=100)	Age Group 13-15 Yrs (n=100)	z Values¶	Age Group 10-12 Yrs (n=100)	Age Group 13-15 Yrs (n=100)	z Values¶
1	**Mid Upper Arm Circumference (MUAC) (cm)**						
i	**M±SD**	20.21±2.37	21.94±2.03	**5.55***	20.32±2.97	21.47±2.65	**2.90***
ii	**Range**	16.00-25.50	17.50-28.00		15.50-28.00	16.00-28.50	
iii	**Standard**	24.47	27.47		24.63	28.00	

iv	**% Deficit**	-17.41	-20.13		-17.50	-23.32	
v	**z Values#**	**17.96***	**27.16***		**14.50***	**24.60***	
2	**Forearm Circumference (cm)**						
i	**M±SD**	19.81±1.48	21.22±1.24		20.13±1.93	21.71±1.69	
ii	**Range**	16.50-23.00	19.00-25.00		17.00-26.00	18.00-27.50	
iii	**Standard**	19.53	22.10	**7.27***	20.13	23.17	**6.17***
iv	**% Deficit/Excess**	+1.43	-3.98		0.00	-6.30	
v	**z Values#**	**1.92**	**7.14***		**0.03**	**8.69***	
3	**Wrist Circumference (cm)**						
i	**M±SD**	13.77±0.80	14.46±0.77	**6.19***	13.97±1.17	15.01±1.21	**6.15***
ii	**Range**	11.50-15.50	12.50-16.50		11.00-17.00	12.50-18.50	
iii	**Standard**	13.73	14.80		13.73	15.37	
iv	**% Deficit/Excess**	+0.29	-2.30		+1.75	-2.34	
v	**z Values#**	**0.48**	**4.42***		**2.07**	**3.01**	

¶ - z values are for between group comparison (i.e. comparison between age groups 10-12 yrs & 13-15 yrs); # - z values are for comparison between data of subjects & standards; * - Significant at both 5 % & 1% levels ($p<0.01$); ** - Significant at 5 % level but insignificant at 1 % level ($0.01<p<0.05$); Values without any mark indicate insignificant difference at both 5% & 1% levels ($p>0.05$).

The mean values for MUAC were recorded as 20.21±2.37 cm, 21.94±2.03 cm, 20.32±2.97 cm and 21.47±2.65 cm for girls aged 10-12 yrs, girls aged 13-15 yrs, boys aged 10-12 yrs and boys aged 13-15 yrs, respectively. Age wise increment was noted in MUAC in both the genders. Girls from 10-12 yrs and 13-15 yrs age groups and boys from 10-12 yrs & 13-15 yrs age groups had significantly lower mean MUAC measurements than the standards ($z=14.50$ to 27.16, $p<0.01$). Lower intake of energy and/or high energy expenditure among basketballers might be the reason of lower mean MUAC measurements. In comparison with the standards, the % deficits for MUAC were calculated as 17.41, 20.13, 17.50 and 23.32 in girls aged 10-12 yrs and 13-15 yrs and boys aged 10-12 yrs and 13-15 yrs, respectively. Older girls and boys showed significantly greater MUAC ($z=5.55$ and 2.90, respectively, $p<0.01$).

Forearm and wrist strength play a big role in the release of basketballer's jump shot. When a shooter jumps, the ball is released toward the basket by snapping or flicking the wrist toward the basket to create backspin. This backspin softens the shot, giving it a better chance to going if it hits the rim. The stronger the wrist snap, the more backspin and air one can get under the shot. Control and accuracy of basketballer's shot depend solely on the strength of their forearm, wrists and fingertips. It may come as a surprise that even "palming" a basketball, or holding it with one hand, also relies more on hand strength than hand size (https://livehealthy.chron.com/hand-size-affect-shooting-ball-3415.html).

Mean values of forearm circumference were recorded as 19.81±1.48 cm, 21.22±1.24 cm, 20.13±1.93 cm and 21.71±1.69 cm for 10-12 yrs and 13-15 yrs aged girls as well as for 10-12 yrs and 13-15 yrs aged boys, respectively. Forearm circumference showed insignificant difference in 10-12 yrs aged girls (% excess: 1.43) and 10-12 yrs aged boys (% deficit: 3.98) when compared with their standards ($z=1.92$ and 0.03, respectively, $p>0.05$), whereas it was significant in case of 13-15 yrs aged girls and boys (% deficit: 6.30) when compared against standards ($z=7.14$ and 8.69, respectively, $p<0.01$). Older group of boys had mean forearm circumference exactly similar to the standard. Older groups of girls and boys were unable to meet the standards for their mean forearm circumference. Both the groups of older girls and boys showed significantly greater mean forearm circumference as compared to younger groups of girls & boys, respectively ($z=7.27$ and 6.17, respectively, $p<0.01$).

Koley, S. et al. (2011) in their study of arm anthropometric profile in 60 Indian inter-university basketball players in Amritsar, indicated statistically significant ($p\leq0.05$-0.01) differences between the male basketball players and the controls in forearm circumference whereas no significant differences were found between the female basketball players and the controls. Hurbob, J. and Jurimaea, T. (2009) studied relationship of handgrip strength with anthropometric and body composition variables in prepubertal children aged between 8 and 11 years (*n*=64, 27 boys, 37 girls) and concluded that forearm girth is the most limiting factors influencing handgrip strength in prepubertal children. In basketball, a number of movements rely on the continuous use of wrist and digit flexors in catching, holding, shooting and passing, so hand strength is fundamental in this game (Cortis, C. A. et al., 2011 & Jurimae, T. & Visnapuu, M., 2007).

Mean values of wrist circumference were recorded as 13.77±0.80 cm, 14.46±0.77 cm, 13.97±1.17 cm and 15.01±1.21 cm for 10-12 yrs and 13-15 yrs aged girls, 10-12 yrs and 13-15 yrs aged boys, respectively (Table 3). Mean wrist circumference was greater than standards among girls and boys aged 10-12 yrs ($z=0.48$ and 2.07, respectively) whereas it was significantly lower than standards among girls & boys aged 13-15 yrs ($z=4.42$ and 3.01, respectively, $p<0.01$). In case of younger girls, the difference was insignificant ($p>0.05$) whereas in case of younger boys, the difference was significant only at 5% level ($0.01<p<0.05$). Older girls & boys had significantly greater mean wrist circumference than younger girls and boys ($z=6.19$ in girls & 6.15 in boys).

Ozturk, A. et al. (2017) studied wrist circumference and frame size percentiles in 6-17-year-old Turkish children and adolescents in Kayseri and found the mean±standard deviation of wrist circumference as 13.00±0.89 cm and 12.48±0.93 cm (6 years) which increased to 16.83±1.16 and 15.58±0.86 cm (17 years), in boys and girls, respectively, and apparently found higher in boys as compared to girls. Fallahi, A. A. and Jadidian, A. A. (2011) studied the effect of hand dimensions, hand shape and some anthropometric characteristics on handgrip strength in male grip athletes and non-athletes and concluded that forearm circumference ($p<0.001$) and wrist circumference ($p<0.001$) were significantly different between the groups.

Nutrient intake:

Energy demands during the basketball season are substantial and may be even higher during off-season training. Choosing foods that provide the energy to support competition and training is essential and can also be quite challenging. Although total energy intake is

important to counteract weight loss during the season, the source of the calories is critical to provide the muscle with the right type of fuel. The body's preferred fuel during high-intensity activities such as basketball is carbohydrate. Basketball players should consume a high-carbohydrate diet; that is to say that at least 55-65% of total calories in the diet should come from food rich in carbohydrate such as cereals, millets, sugars, starches, fruits, vegetables, etc. The range of carbohydrate intake suggested for basketball players is 5-7 (and up to 10) g/kg body weight depending upon playing time and the time of year (preseason, in-season, or postseason). Protein is very important nutrient for actual athletic performance. A sufficient protein intake is important for the building of muscle mass and the recovery of damaged tissues. It is generally known that an increased need for protein is found in children and adolescent athletes because as they start with regular physical training, muscle mass builds up. The recommendation for daily protein intake for basketball players is 1.4-1.7 g/kg of body weight. Besides protein & carbohydrates, dietary fats are important for the synthesis of hormones and cell membranes, as well as proper immune function. Athletes should strive to eat heart-healthy fats such as mono-unsaturated fats as well as omega-3 fats and avoid saturated fats and trans fats present in processed foods. Energy intake from fat should make up the remainder of calories after protein and carbohydrate recommendations are met. The role of nutrition in sports performance is very important. Proper nutrition must be available prior, during and post competition (Osterberg, K., 2017 and Indoria, A. and Singh, N., 2016).

Data on daily mean intake of energy, carbohydrates, protein and fat by basketballers is demonstrated in Table 4.

Table 4: Data on Daily Mean Intake of Energy, Carbohydrate, Protein and Fat by Basketballers

Sr. No.	Parameters	GIRLS			BOYS		
		Age Group 10-12 Yrs (n=100)	**Age Group 13-15 Yrs (n=100)**	**z Values ¶**	**Age Group 10-12 Yrs (n=100)**	**Age Group 13-15 Yrs (n=100)**	**z Values ¶**
1	**Energy (kcal)**						
i	**M±SD**	1865±282	2242±204	**10.88***	2181±159	2479±183	**12.27***
ii	**Range**	1280-2359	1521-2714		1792-2557	2000-2806	
iii	**RDA**	2010	2330		2190	2750	
iv	**% Deficit**	-7.24	-3.76		-0.41	-9.87	
v	**z Values#**	**5.17***	**4.31***		**0.57**	**14.80***	
2	**Carbohydrate (g)**						
i	**M±SD**	314.91±55.05	380.37±33.90	**10.12***	372.79±26.05	411.08±35.04	**8.77***
ii	**Range**	188.26-404.89	242.80-455.55		311.63-430.82	311.74-471.41	
3	**Protein (g)**						
i	**M±SD**	48.41±7.57	58.84±7.22	**9.97***	56.90±5.90	64.02±5.00	**9.21***
ii	**Range**	29.99-64.24	37.31-72.54		41.52-68.51	52.93-72.64	
iii	**RDA**	40.40	51.90		39.90	54.30	
iv	**%Excess**	+19.83	+13.37		+42.61	+17.90	

v	**z Values#**	**10.58***	**9.62***		**28.82***	**19.44***	
4	**Fat (g)**						
i	**M±SD**	45.69±6.49	53.94±7.97	**8.03***	51.35±6.30	64.26±5.79	**15.09***
ii	**Range**	35.07-60.63	37.79-72.41		37.67-66.29	51.41-78.21	

¶ - z values are for between group comparison (i.e. comparison between age groups 10-12 yrs & 13-15 yrs); # - z values are for comparison between data of subjects & standards; * - Significant at both 5 % & 1% levels ($p<0.01$); ** - Significant at 5 % level but insignificant at 1 % level ($0.01<p<0.05$); Values without any mark indicate insignificant difference at both 5% & 1% levels ($p>0.05$).

Irrespective of the age and gender, all the groups of players had lower mean daily intake of energy than RDAs (1865±282 kcal, 2242±204 kcal, 2181±159 kcal and 2479±183 kcal in girls from 10-12 yrs, 13-15 yrs age groups and boys from 10-12 yrs, 13-15 yrs age groups, respectively). Deficit intake of energy can lead to compromised work capacity.

Nande, P. et al. (2008) assessed energy intake and expenditure in 59 players (13 female & 46 male players), aged 18-22 years, engaged in different sports disciplines such as athletics, volleyball, cricket, judo, gymnastics, weight lifting, hurdle racing, half marathon, badminton, cross country etc. and found that irrespective of the sport group, female players ($t=3.62$, $p<0.01$) and male players ($t = 8.05$, $p<0.01$) showed mean intakes of energy below their respective RDA's. Cabral, C. A. C. et al. (2006) aimed to diagnose the nutritional status of the 24 athletes from weight lifting permanent Olympic team of the Brazilian Olympic Committee, aged 16-23 yr, 12 males (19.7±2.4 yr) and 12 females (19.2±1.8 yr) and in the study, 83% of the athletes presented energy intake below the recommended values, considering the high level of physical activity, resulting in daily caloric deficiency.

For the present research, the mean energy intake by younger group of boys was found to be greater than that of younger girls. Similarly, mean energy intake by older group of boys was found to be greater than that of older girls. A difference of 316 kcal was observed between the mean intake of energy intake by girls and boys aged 10-12 yrs whereas it was 237 kcal in case of girls and boys aged 13-15 yrs. Older group of female players consumed significantly higher amounts of energy than younger group of female players ($z=10.88$). Similarly, older group of male players consumed significantly higher amounts of energy than younger group of male players ($z=12.27$). The mean energy intake among girls (10-12 yrs), girls (13-15 yrs), boys (10-12 yrs) and boys (13-15 yrs) was calculated as 49.91, 47.59, 60.41 and 55.69 kcal/kg actual mean body weight/day, respectively. Majority of basketballers consumed daily energy intake below RDA. Unfortunately, 71% of 13-15 yrs aged male basketballers were found to have energy intake below RDA followed by 52% of 10-12 yrs aged girls, 50% of 13-15 yrs aged girls and then 31% of 10-12 yrs aged boys. 21%, 31%, 50% and 24% of girls from 10-12 yrs and 13-15 yrs age groups and boys from 10-12 yrs and 13-15 yrs age groups, respectively consumed adequate intake of energy in their diets. Also, 5%, 19%, 19% and 27% of girls (10-12 yrs), girls (13-15 yrs), boys (10-12 yrs) & boys (13-15 yrs) respectively showed daily energy intake above RDAs.

Mean carbohydrate intake by girls aged 10-12 yrs, girls aged 13-15 yrs, boys aged 10-12 yrs &boys aged 13-15 yrs was 314.91±55.05, 380.37±33.90, 372.79±26.05 and 411.08±35.04 g, respectively which was found to be increased with age in both the genders.

The mean intake of carbohydrate in girls aged 13-15 yrs was higher by 65.46 g than in girls aged 10-12 yrs (z=10.12) whereas it was higher by 38.29 g in boys aged 13-15 yrs as compared to boys aged 10-12 yrs (z=8.77). This is because older groups in both genders had higher energy intake and a major portion of energy came from carbohydrate in their diets. The mean intake of carbohydrate per kg actual body weight was calculated as 8.42, 8.07, 10.32 and 9.23 g/kg/day for girls aged 10-12 yrs and 13-15 yrs and boys aged 10-12 yrs and 13-15 yrs, respectively.

Mean values of daily protein intake for all the groups of basketballers were found to be significantly higher than RDAs (z=10.58, 9.62, 28.82 and 19.44, respectively for girls aged 10-12 yrs, girls aged 13-15 yrs, boys aged 10-12 yrs and boys aged 13-14 yrs, $p<0.01$). The mean values for daily protein intake were recorded as 48.41±7.57 g, 58.84±7.22 g, 56.90±5.90 g and 64.02±5.00 g with % excess (in comparison with RDAs) of 19.83, 13.37, 42.61 and 17.90 %, respectively for girls aged 10-12 yrs, girls aged 13-15 yrs, boys aged 10-12 yrs & boys aged 13-15 yrs. In comparison to girls, boys showed far higher mean protein intake than RDAs which was clearly reflected from z values (Table 4).

The difference in the mean intake of protein by younger & older groups of girls i.e. 10-12 yrs and 13-15 yrs was found to be 10.43 g whereas the difference was 7.12 g between younger & older groups of boys i.e. 10-12 yrs and 13-15 yrs. The older groups of girls & boys showed significantly higher mean daily intake of protein than younger groups of girls & boys (z=9.97 for girls aged 10-12 yrs vs. girls aged 13-15 yrs and z=9.21 for boys aged 10-12 yrs vs. boys aged 13-15 yrs)($p<0.01$). The mean protein intake per kg body weight per day was derived as 1.29 g, 1.24 g, 1.57 g and 1.43 g, respectively for girls aged 10-12 yrs, girls aged13-15 yrs, boys aged 10-12 yrs and boys aged 13-15 yrs. Younger group of male basketballers consumed higher mean daily protein than younger group of female basketballers & a difference of 8.49 g was noted between them for mean daily protein intake. Similarly, older group of male basketballer consumed 5.18 g excess mean daily protein than older group of female basketballers. Majority of the basketballers i.e. 36% of girls aged 10-12 yrs , 46% of girls aged 13-15 yrs, 83% of boys aged 10-12 yrs and 75% of boys aged 13-15 yrs consumed excess protein in their diets. 59% girls (10-12 yrs), 49% girls (13-15 yrs), 17% boys (10-12 yrs) and 24% boys (13-15 yrs) had adequate intake of protein whereas 5% from each group of female players and 1% of boys aged 13-15 yrs reported to have protein intake below RDAs.

Similar to protein intake, mean daily intake of fat was also higher in older groups than younger groups of basketballers. The differences in the mean fat intake between 10-12 yrs & 13-15 yrs age groups were recorded as 8.25 g in girls and 12.91 g in boys. Mean fat intake was derived as 45.69±6.49 g, 53.94±7.97 g, 51.35±6.30 g and 64.26±5.79 g, respectively for girls aged 10-12 yrs, girls aged 13-15 yrs, boys aged 10-12 yrs and boys aged 13-15 yrs. Older age groups of female and male basketballers consumed significantly higher mean daily fat than younger groups of female and male basketballers (z=8.03 for girls aged 10-12 yrs vs. girls aged 13-15 yrs and z=15.09 for boys aged 10-12 yrs vs. boys aged 13-15 yrs, $p<0.01$). Fat intake in girls aged 10-12 yrs, girls aged 13-15 yrs, boys aged 10-12 yrs and boys aged 13-15 yrs was found as 1.22, 1.14, 1.42 and 1.44 g/kg/, respectively.

Hand grip strength:

Handgrip strength is important for any sport in which the hands are used for catching, throwing or lifting. Also, as a general rule people with strong hands tend to be strong elsewhere, so this test is often used as a general test of strength (http://www.topendsports.com/testing/tests/handgrip.htm). Assessment of handgrip muscle strength tests has been a popular form of testing muscle function in sports and exercise as well as in other movement related sciences for several decades. It is often used as an indicator of the overall physical strength. Handgrip strength testing has been extensively employed in a number of sport disciplines to select young athletes, to distinguish among different performance levels, or to evaluate the effects of physical exercise in athletic training procedures (Richards, L. et al., 1996).

Table 5 shows the data on hand grip strength test of basketballers.

Table 5: Data on Hand Grip Strength Test of Basketballers

Sr. No.	SUBJECTS	PARAMETERS	Hand Grip (Kg)		z Values¶
			Age Group 10-12 Yrs (n=100)	Age Group 13-15 Yrs (n=100)	
1	**G I R L S**	**Mean±SD**	24.99±6.04	29.08±5.78	**4.89***
		Range	14.00-36.00	15.00-41.00	
		Performance Assessment Based on Mean	**Good**	**Good**	
2	**B O Y S**	**Mean±SD**	27.16±6.64	31.26±6.07	**4.56***
		Range	15.00-65.00	16.00-43.00	
		Performance Assessment Based on Mean	**Fair**	**Poor**	
z Values■			**2.42****	**2.60***	-

¶ - z values are for between group comparison (i.e. comparison between age groups 10-12 yrs & 13-15 yrs); ■ - z values are for between gender comparison (i.e. comparison between girls & boys from age group 10-12 yrs & between girls & boys from age group 13-15 yrs); * - Significant at both 5 % & 1% levels ($p<0.01$); ** - Significant at 5 % level but insignificant at 1 % level ($0.01<p<0.05$); Values without any mark indicate insignificant difference at both 5% & 1% levels ($p>0.05$).

Mean values for grip strength test were found to be higher in male players from age groups 10-12 & 13-15 yrs (27.16±6.64 kg & 31.26±6.07 kg, respectively) as compared to female players from age groups 10-12 & 13-15 yrs (24.99±6.04 kg & 29.08±5.78 kg, respectively) showing more strength in the forearms and hands among boys. The younger & older groups of boys possessed significantly more powerful handgrip than the younger & older groups of girls, respectively [$z=2.42$ for younger girls vs. younger boys ($0.01<p<0.05$) and $z=2.60$ for older girls vs. older boys ($p<0.01$)]. Tsakalou, L. et al. (2015) confirmed that the increase rate of body mass, as long as the hyper secretion of the male hormone

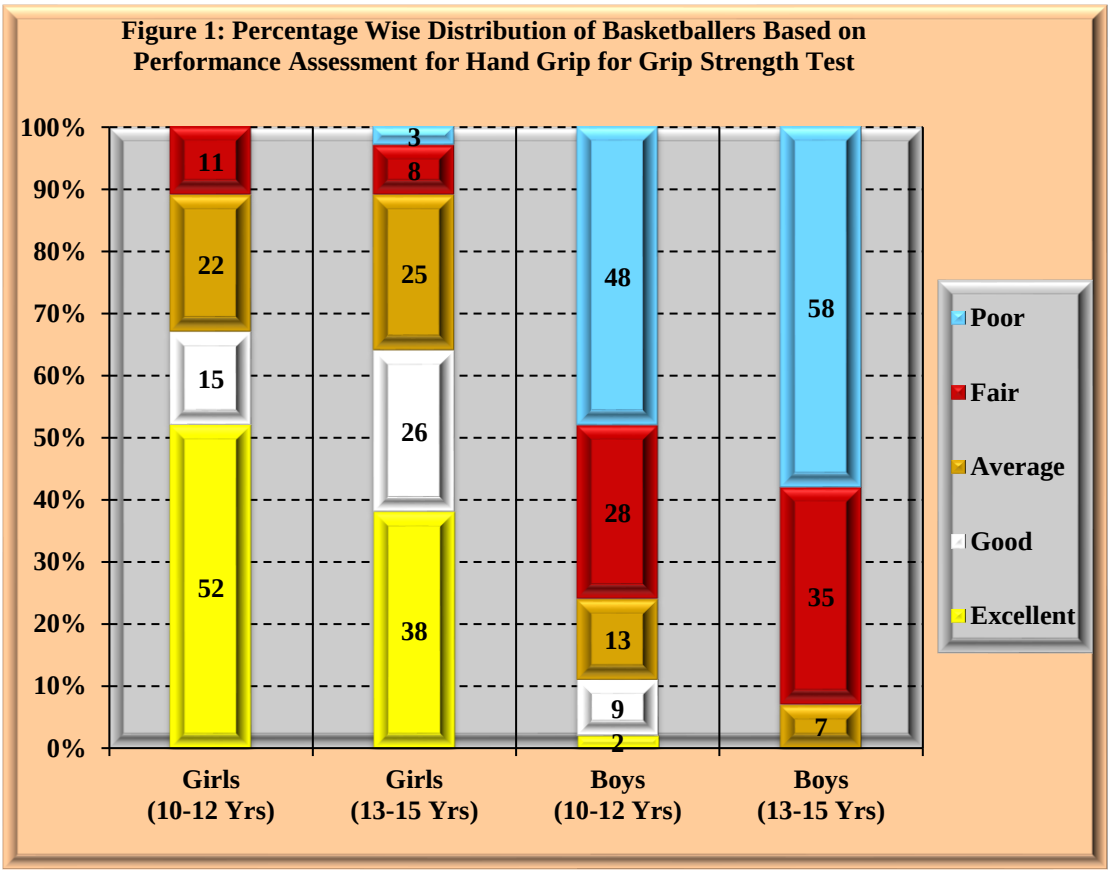
(testosterone) that take place near the age of 13-14 yrs old, contribute as much to maximizing the differences between male and female as to the correlation of handgrip and ball velocity at this age.

Here, for this study, female players from both the age groups of 10-12 & 13-15 yrs were rated 'good' for their hand grip performance whereas it was 'fair' for boys aged 10-12 yrs and 'poor' for boys aged 13-15 yrs. Even though boys possessed higher mean readings for hand grip strength than girls, on the basis of the norms for age their ratings were inferior to girls (Table 5). Within gender age wise comparisons for mean hand grip strength revealed that older groups of female & male basketballers possessed significantly powerful hand grip than younger groups of female & male basketballers, respectively ($z=4.89$ for girls & 4.56 for boys, $p<0.01$). The results confirm the fact that there found increment in the hand grip power as the age progressed & also, it can be attributed to longer engagement in the game by older players.

During basketball play, both hands are used in techniques and tactics such as left and right hand rebounding, lay ups, deflection, passing, fake and feints. The dominant hand is used mostly for shooting, passing and dribbling. Handgrip strength is a basilar component not only in these basketball basic moves but also in defensive and offensive maneuvers and the repetition of these tasks is an athletic career effect (Pizzigalli, L. et al., 2017).

Figure 1 shows the percentage wise distribution of basketballers based on performance assessment for hand grip for grip strength test.

Figure 1: Percentage Wise Distribution of Basketballers Based on Performance Assessment for Hand Grip for Grip Strength Test



Majority of female players from 10-12 yrs age group (52%) & 13-15 yrs age group (38%) showed 'excellent' hand grip strength whereas only 2% of boys from 10-12 yrs age

group reflected 'excellent' handgrip muscle strength. 15% of female players from 10-12 yrs age group, 26% of females from 13-15 yrs age group and 9% of boys from 10-12 yrs age group were 'good' in their performance for the grip strength test. As seen in Figure 4.47, 22-25% of female players and 7-13% of male players were categorized as 'average 'for their hand grip strength.

Koley, S. et al. (2011) studied arm anthropometric profile in 60 Indian inter-university basketball players (aged 18-25 years) in Amritsar & the results indicated statistically significant ($p \leq 0.05$-0.01) differences between the male basketball players and the controls in handgrip strength, whereas no significant differences were found between the female basketball players and the controls. Jurimae, T. and Visnapuu, M. (2007) studied the influence of general body and hand-specific anthropometric dimensions on handgrip strength in 193 basketballers aged 10-17 yrs and observed that general anthropometric parameters determined the maximal handgrip strength more accurately than did specific hand anthropometric parameters among players. Pizzigalli, L. et al. (2017) studied hand grip strength and anthropometric characteristics in Italian female national basketball teams (under 14 to senior) and found that handgrip strength increased, raising the statistical significant differences only for players from the age of 19 (U20, Seniors) with respect to sub-elite groups (U14, U15) ($p<0.05$). Fallahi, A. A. and Jadidian, A. A. (2011) studied the effect of hand dimensions, hand shape and some anthropometric characteristics on handgrip strength in male grip athletes and non-athletes and found a significant difference between the two groups in absolute handgrip strength ($p<0.001$). Wagh, P. D. et al. (2017) determined muscular strength by handgrip dynamometer in 50 sportsmen (involved in various sports activities like basketball, cricket, hockey, tennis, and handball) and 50 students as control group aged between 18-25 years and it was reported that muscle strength in sportsmen (47.74±4.67) kg was higher than in control group (41.60±4.67) kg.

Correlates of hand measurements and nutrient intake with hand grip strength:

For the present study, among groups of older & younger boys, there was strong & significant association ($p<0.01$) was found out for correlation of palm width & length with arm length ($r=0.3013$ & 0.4995 and $r=0.6004$ & 0.8175, respectively), arm span ($r=0.4926$ & 0.5788 and 0.7123 & 0.8628, respectively) & hand span ($r=0.5087$ & 0.7120 and 0.5681 & 0.7497, respectively).

Among girls aged 10-12 & 13-15 yrs, the association of palm width with hand span as well palm length with hand span was positive & significant ($r=0.4668$ & 0.4118, $p<0.01$ and $r=0.5051$ & 0.4673, $p<0.01$, respectively). The greater the hand contact area is, the greater it enables a player to command better control over ball.

Unlike boys, among girls from both age groups, correlation of palm width with arm length & arm span was not significant, however, correlation of palm length with arm length ($r=0.5964$ & 0.5469, respectively for 10-12 yrs & 13-15 yrs) & arm span ($r=0.7047$ & 0.6472, respectively for 10-12 yrs & 13-15 yrs) was significant & positive ($p<0.01$). In general, boys show strong correlation of palm width with all the hand parameters as compared to girls. It might be due to more strengthening of muscles involved in palming in boys as compared to girls.

Singh, K. and Ram, M. (2013) studied kinanthropometric profile of University level 42 male basketball players (18-25 yrs) as a predictor of basketball players strength measures

and concluded that the correlations of body weight, standing height, arm length and hand length were positive and significant at 0.01 level of significance, whereas correlation of hand breadth was positive and insignificant with strength measures of basketball players.

Fallahi, A. A. and Jadidian, A. A. (2011) studied the effect of hand dimensions, hand shape and some anthropometric characteristics on handgrip strength in male grip athletes and non-athletes and concluded that hand shape and palm length were not significantly different between the groups ($p>0.05$) whereas it was reverse in case of palm width ($p<0.001$).

The taller were the basketballers with longer arm length & arm span, longer were the lengths of index finger & ring finger. Among girls aged 10-12 yrs, girls aged 13-15 yrs, boys aged 10-12 yrs & boys aged 13-15 yrs, index finger & ring finger lengths demonstrated significant & positive correlations ($p<0.01$) with height ($r=0.3227$ to 0.8033), arm length ($r=0.2946$ to 0.7739) & arm span ($r=0.3985$ to 0.8014) & these correlations were more pronounced among boys.

Index finger length & ring finger length of females & males aged 10-12 yrs & 13-15 yrs reflected strongly significant & positive relationship with hand characteristics like hand span, palm width & palm length ($r=0.4361$ to 0.7211, $r=0.2209$ to 0.6706 & $r=0.5914$ to 0.8619, respectively). Both these finger lengths showed very strong correlations with the length of palm among players from both the genders, hence, indicating the fact that longer are the palms longer are the index & ring fingers.

In basketball, a number of movements rely on the continuous use of wrist and digit flexors in catching, holding, shooting and passing, so hand strength is fundamental in this game (Cortis, C. A. et al., 2011 & Jurimae, T. and Visnapuu, M., 2007).

Among younger groups of girls & boys, there existed inverse relationship for MUAC vs. arm length ($r= -0.0429$ & -0.1952, respectively, $p>0.05$) as well as for forearm circumference vs. arm length ($r= -0.0809$ & -0.2838, respectively, $p>0.05$). In contrast to this, among older groups of girls & boys, the correlations between MUAC & arm length ($r= 0.1335$ & 0.1600, respectively) as well as between forearm circumference & arm length ($r= 0.1700$ & 0.4437, respectively) were found to be positive but not significant ($p>0.05$). Among all four groups of basketballers, wrist circumference correlated directly & significantly with arm length ($r=0.0115$ to 0.4930). These results are the indication of gain in MUAC, forearm circumference & wrist circumference among older groups of female & male basketballers may be owing to gain in muscle mass which is a good effect of sports engagement. However, gain in these girths can also be attributed to fat mass since the players were from the age group of pubertal period.

Among girls aged 10-12 yrs, girls aged 13-15 yrs, boys aged 10-12 yrs & boys aged 13-15 yrs, MUAC found to be positively correlated with arm span ($r= 0.1813$, 0.1935, 0.4520 & 0.2409, respectively) & hand span ($r=0.2878$, 0.0935, 0.3070 & 0.3168, respectively), the correlations were significant for both the groups of boys but insignificant for both the groups of girls for the former & insignificant for older girls for the later. MUAC, forearm circumference & wrist circumference showed significant & positive correlation with ($r=0.2392$ to 0.7050) & palm length ($r=0.2034$ to 0.5940) in all four groups of basketballers.

Wrist circumference is an indicator of frame size. For this study, there found significantly ($p<0.01$) positive correlation of wrist circumference with hand span ($r= 0.3550$, 0.3588, 0.4299 & 0.5637, respectively for girls aged 10-12 yrs, girls aged 13-15 yrs, boys

aged 10-12 yrs & boys aged 13-15 yrs) among all four groups of basketballers, thereby, indicating the fact that broader the wrist greater is the span of the hand.

Gryko, K. et al. (2018) revealed significant positive correlations between body mass, body height, flexed arm girth and playing position (guards, forwards & centers) whereas moderate positive correlations to playing position (guards, forwards & centers) were noted in arm span, calf girth, relaxed arm girth, shoulder breath and BMI in professional basketball players (n=35, 14.09±0.30 years).

For the present study, among female basketballers aged 10-12 yrs, female basketballers aged 13-15 yrs, male basketballers aged 10-12 yrs, male basketballers aged 13-15 yrs, the intakes of energy, carbohydrate, protein & fat reflected significant ($p<0.01$) & positive correlations with hand span ($r=0.1312, 0.3009, 0.4286$ & 0.4350 for energy intake, respectively; $r=0.0890, 0.2637, 0.4056$ & 0.4025 for carbohydrate intake, respectively; $r=0.1751, 0.2585, 0.3953$ & 0.3784 for protein intake, respectively and $r=0.2059, 0.2512, 0.2922$ & 0.3030 for fat intake, respectively) and palm width ($r=0.3372, 0.1501, 0.4850$ & 0.4736 for energy intake, respectively; $r=0.3151, 0.1205, 0.4469$ & 0.4354 for carbohydrate intake, respectively; $r=0.3161, 0.1366, 0.4601$ & 0.4079 for protein intake, respectively and $r=0.2737, 0.1429, 0.3477$ & 0.3391 for fat intake, respectively). These results indicate the importance of energy & macronutrients for players in this growing age.

Among female basketballers aged 10-12 yrs & 13-15 yrs as well as among male basketballers aged 10-12 yrs & 13-15 yrs, intakes of energy, carbohydrate, protein & fat showed significant ($p<0.01$) & positive correlations with arm length ($r=0.1798, 0.1315, 0.3018$ & 0.2203, respectively for energy intake; $r=0.1725, 0.0912, 0.2761$ & 0.1978, respectively for carbohydrate intake; $r=0.2217, 0.1921, 0.0988$ & 0.1830, respectively for protein intake and $r=0.1017, 0.1234, 0.2982$ & 0.1730, respectively for fat intake); arm span ($r=0.3303, 0.3370, 0.5007$ & 0.3235, respectively for energy intake; $r=0.3049, 0.3283, 0.4669$ & 0.2657, respectively for carbohydrate intake; $r=0.3614, 0.2589, 0.2459$ & 0.3070, respectively for protein intake and $r=0.2556, 0.2310, 0.4441$ & 0.3060, respectively for fat intake, respectively); palm length ($r=0.3836, 0.2252, 0.5094$ & 0.3278, respectively for energy intake; $r=0.3480, 0.2213, 0.4783$ & 0.2831, respectively for carbohydrate intake; $r=0.4135, 0.1715, 0.3795$ & 0.3312, respectively for protein intake and $r=0.3226, 0.1515, 0.3919$ & 0.2650, respectively for fat intake); index finger length, ($r=0.2224, 0.2007, 0.3537$ & 0.3077, respectively for energy intake; $r=0.2057, 0.2088, 0.3300$ & 0.2529, respectively for carbohydrate intake; $r=0.1862, 0.2051, 0.2875$ & 0.2600, respectively for protein intake and $r=0.2001, 0.0921, 0.2661$ & 0.3029, respectively for fat intake); ring finger length ($r=0.3063, 0.2942, 0.4180$ & 0.2862, respectively for energy intake; $r=0.3007, 0.2971, 0.3838$ & 0.2259, respectively for carbohydrate intake; $r=0.2937, 0.2467, 0.3271$ & 0.3618, respectively for protein intake and $r=0.1905, 0.1737, 0.3310$ & 0.2608, respectively for fat intake). These results of coefficient of correlation show that intake of energy, carbohydrate, protein & fat are effective among active children for determination of body segment lengths.

Body girths are highly influenced by dietary intake of energy. In the present study, energy intake depicted highly strong positive & significant correlation with different body girths like MUAC ($r=0.6019, 0.6419, 0.7388$ & 0.6534, respectively, $p<0.01$); forearm circumference ($r=0.6603, 0.6727, 0.7809$ & 0.6403, respectively, $p<0.01$); wrist

circumference (r=0.5409, 0.5431, 0.6464 & 0.5280, respectively, p<0.01) in girls aged 10-12 yrs, girls aged 13-15 yrs, boys aged 10-12 yrs & boys aged 13-15 yrs, respectively.

Similar to energy intake, among all four groups of basketballers (i.e. girls aged 10-12 yrs, girls aged 13-15 yrs, boys aged 10-12 yrs & boys aged 13-15 yrs), carbohydrate intake reflected strong positive & significant correlations with MUAC (r=0.5676, 0.5891, 0.7184 & 0.5535, respectively, p<0.01); forearm circumference (r=0.6313, 0.6125, 0.7441 & 0.5613, respectively, p<0.01); wrist circumference (r=0.5131, 0.4436, 0.6269 & 0.4399, respectively, p<0.01). Carbohydrates through the diets if not utilized, are stored as adipose tissues. Here, among basketballers, intake of carbohydrate resulted in fat deposition & hence, there were direct relationship existed between carbohydrate intake & all body circumferences.

Among girls (10-12 yrs), girls (13-15 yrs), boys (10-12 yrs) & boys (13-15 yrs), protein intake also showed moderate to strong correlations which were significant (p<0.01) with MUAC (r=0.5515, 0.3896, 0.5971, 0.4821, respectively); forearm circumference (r=0.5724, 0.4099, 0.6158 & 0.4788, respectively); wrist circumference (r=0.5341, 0.3634, 0.4980 & 0.4764, respectively. The coefficients of correlations were found to decrease with age in both the genders. Protein intake reflected highest correlation with MUAC in boys aged 10-12 yrs and 13-15 yrs which shows that higher intake of protein in boys might helped them develop muscle in mid upper arm area.

Fat is the concentrated source of dietary energy. For the present research, like other two macronutrients-carbohydrate & protein, fat intake among girls aged 10-12 yrs, girls aged 13-15 yrs, boys aged 10-12 yrs & boys aged 13-15 yrs demonstrated significant positive correlation with MUAC (r=0.4756, 0.5505, 0.5036 & 0.6260, respectively, p<0.01); forearm circumference (r=0.5064, 0.5853, 0.5665 & 0.5599, respectively, p<0.01); wrist circumference (r=0.3961, 0.5558, 0.4537 & 0.4919, respectively, p<0.01).

The results of correlates of energy & energy giving nutrients clearly indicate the important role of diet balanced in carbohydrate, protein & fat in attaining required physical dimensions during the period of growth.

Hand grip strength test performance [r=0.1318 (p>0.05) & 0.3051 (p<0.01)] correlated positively with hand span. The results show that hand span is important measure in determining the optimum grip-span for grip strength test performance. Palm width is also known as hand breadth which is very important in the sport like basketball where there is a need to hold the ball firm before throwing into the basket. Wider are the palms firm is the grip (Visnapuu, M. and Jurimae, T., 2007). Foo, L. H. et al. (2007) opined that handgrip strength determines the muscular strength of an individual. Broader were the palms; greater was the strength of the grip among basketballers. Grip strength test performance depicted positive correlation with palm width in girls aged 10-12 yrs, girls aged 13-15 yrs, boys aged 10-12 yrs & boys aged 13-15 yrs [r=0.3200 (p<0.01); r=0.0032 (p>0.05); r=0.0525 (p>0.05) & r=0.3094 (p<0.01), respectively]. Grip strength test performance had negative correlation with arm length in older girls and younger boys (r= -0.1906 & -0.0034, respectively, p>0.05). Longer arms make it easier to reach the ball, catch it and help with jump shots. Hager-Ross, C. and Schieber, M. H. (2000) investigating children at different ages, confirmed that hand length (the distance from wrist joint to the tip of middle finger) is an important variable for handgrip strength. Similarly, in all four age groups of basketballers under the present research, grip strength test performance (r=0.0298 to 0.2909, p>0.05) also found to have

positive correlations with arm span which was observed significant in younger girls and older boys, results indicate that arm span also plays a role in reaching and tackling the ball in this game. Among girls aged 10-12 yrs and boys aged 13-15 yrs, grip strength test performance depicted significant and positive correlation with palm length ($r=0.3158$ & 0.3283, respectively, $p<0.01$) & insignificant & positive in boys aged 10-12 yrs ($r=0.0821$, $p>0.05$). Subjects had longer palms and results suggest that larger hand surfaces lead to stronger grip power. Although, the correlation of grip strength test performance with palm length was negative in girls aged 13-15 yrs ($r= -0.0259$, $p>0.05$).

Sevinc, D. & Yilmaz, V. (2017) investigated the relationship between physical fitness levels of performance and anthropometric characteristics of male athletes aged 9-12 years old taekwondoists and performance of hand grip strength test was found to be significantly and positively correlated with the anthropometric features like arm span, arm length, and palm length. Tsakalou, L. et al. (2015) compared the performance of handgrip strength and ball velocity between boys and girls of two different age groups (12 and 13 years) of 121 adolescent handball players and consequently investigated the correlation between these two parameters and observed that the handgrip strength presented a significantly positive correlation with palm length and palm width in both groups but negative with hand span. The strength of a hand grip is the result of forceful flexion of all finger joints, thumbs and wrists with the maximum voluntary force that the subject is able to exert under normal biokinetic conditions. Handgrip strength is important for catching and throwing the ball in different team sports. In grip sports like basketball, the longer the finger, the better the accuracy of the shot or throw (Fallahi, A. A. & Jadidian, A. A., 2011).

Hand grip strength test performance were found to have positive correlation with index finger length & ring finger length in girls of 10-12 yrs age group, girls of 13-15 yrs age group, boys of 10-12 yrs age group & boys of 13-15 yrs age group, respectively [$r=0.0874$, 0.0499, 0.0157 & 0.1844, respectively, $p>0.05$ for index finger length and $r=0.2889$ ($p<0.01$), 0.2285 ($0.01<p<0.05$), 0.0870 ($p>0.05$) & 0.2682 ($p<0.01$), respectively for ring finger length]. Nicolay, C. W. and Walker, A. L. (2005) assessed relationships between anthropometric variation and grip performance for 51 individuals college students, aged 18-33 yrs and showed that there was a significant but low correlation between finger length and hand grip strength.

Hand grip strength test performance [$r=0.0223$ ($p>0.05$) to 0.2565 ($p<0.01$)] found to be correlated positively with MUAC in all four age groups of basketballers which can be attributed to the muscular development of upper arm which gave general strength that in girls aged 10-12 yrs, girls aged 13-15 yrs, boys aged 10-12 yrs & boys aged 13-15 yrs, grip strength test performance depicted positive association with forearm circumference ($r=0.3135$, 0.0804, 0.0646 & 0.2182, respectively, $p>0.05$). Forearm and wrist are thoroughly involved in gripping activities and are important in determining the grip strength in players hence, showed positive correlation with grip strength test performance. Correlation between grip strength test performance and wrist circumference was significantly positive in girls aged 10-12 yrs & boys aged 13-15 yrs ($r=0.2559$ & 0.2846, respectively, $p<0.01$) and insignificantly positive in girls aged 13-15 yrs & boys aged 10-12 yrs ($r=0.1553$ & 0.0674, respectively, $p>0.05$). Koley, S. et al. (2011) studied the correlations of handgrip strength and some anthropometric variables in 101 Indian inter-university female handball players aged

18-25 years and concluded that dominant right handgrip strength had significantly positive correlation ($p \leq 0.01$) with MUAC. The effect of hand dimensions, hand shape and some anthropometric characteristics on handgrip strength in male athletes (n=40) and non-athletes (n=40) aged between 19 and 29 was studied by Fallahi, A. A. and Jadidian, A. A. (2011) and they observed that handgrip strength significantly correlated with forearm circumference and wrist circumference in athletes. Hurbob, J. and Jurimaea, T. (2009) studied relationship of handgrip strength with anthropometric and body composition variables in prepubertal children aged between 8 and 11 years (n=64, 27 boys, 37 girls) and found that handgrip strength was significantly correlated to arm, forearm and wrist girths.

CONCLUSION:

In conclusion, this study elucidates the significant correlations between hand measurements, energy and carbohydrate, protein and fat intake, and hand grip strength in adolescent basketball players. The findings reveal that anthropometric characteristics of the hand are positively associated with hand grip strength. Additionally, dietary intake, specifically higher energy and macro-nutrient consumption, is linked to enhanced grip strength. These results underscore the importance of tailored nutritional strategies and targeted physical training focused on hand strength to optimize performance in young basketball athletes. Future research should explore the longitudinal impacts of these factors and consider the role of other nutritional and training variables in athletic development. The insights from this study can be instrumental in guiding coaches, nutritionists, and sports scientists in developing comprehensive training regimens that promote optimal physical development and performance in adolescent basketball players.

REFERENCES

- American College of Sports Medicine. Nutrition and athletic performance. Medicine & Science in Sports & Exercise, 2016, 48(3), 543-568.
- Barut, C. Demirel, P. and Kiran, S. Evaluation of Hand Anthropometric Measurements and Grip Strength in Basketball, Volleyball and Handball Players. *Anatomy*, 2008, 2: 55-59; Citation from: http://dergipark.gov.tr/download/article-file/371735; Retrieved on: 19th December, 2018.
- Beck, K. L., Thomson, J. S., Swift, R. J., & von Hurst, P. R. Role of nutrition in performance enhancement and postexercise recovery. Open Access Journal of Sports Medicine, 2015, 6, 259-267.
- Beunen, G. and Malina, R. M. Growth and Physical Performance Relative to the Timing of the Adolescent Spurt.Exercise and Sport Sciences Reviews, 1988, 16, 503-540; Citation from: https://efsupit.ro/images/stories/nr4.2015/Art122.pdf; Retrieved on: 20th December, 2018.
- Cabral, C. A. C. Rosado, G. P. Silva, C. H. and Marins, J. C. Diagnosis of the Nutritional Status of The Weight Lifting Permanent Olympic Team of The Brazilian Olympic Committee. *Rev Bras Med Esporte*, 2006, 12(6): 308-312; Citation from: https://pdfs.semanticscholar.org/0638/c6833040948893dd0102f00 d87c96f89b8a5.pdf; Retrieved on: 17th January, 2019.

- Chisi, J. and Zverev, Y. Arm Span and Height in Malawian Children. *Collegium Antropologicum,* 2005, 29: 469-473. Citation from: https://www.ajol.info/index. php/njp/article/download/89981/79449; Retrieved on: 19th December, 2018.
- Cortis, C. Tessitore, A. Lupo, C. Pesce, C. Fossile, E. & Figura, F. Inter-Limb Coordination, Strength, Jump, and Sprint Performances Following a Youth Men's Basketball Game. *Journal of Strength and Conditioning Research*, 2011, 25(1): 135-142; Citation from: https://www.academia.edu/19495088/Inter-Limb_ Coordination_Strength_Jump_and_Sprint_Performances_Following_a_Youth_Men%CA %BCs_Basketball_Game; Retrieved on: 22ndFebruary, 2016.
- Davis, B. et al. 2000. Physical Education and the Study of Sport; Citation from: http://orgbooktin.com/physical-education-the-study-of-sport-bob-davis-last-modified-full-book.pdf; Retrieved on: 2nd February, 2019.
- Engstrom, F. M. Roche, A. F. & Mukherjee, D. Differences between Arm Span and Stature in White Children. *The Journal of Adolescent Health care,* 1981, 2(1):19-22; Citation from: https://www.ncbi.nlm.nih.gov/pubmed/7333939; Retrieved on: 10th February, 2019.
- Fallahi, A. A. and Jadidian, A. A. The Effect of Hand Dimensions, Hand Shape and Some Anthropometric Characteristics on Handgrip Strength in Male Grip Athletes and Non-Athletes. *Journal of Human Kinetics*, 2011, 29: 151-159; Citation from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3588620/; Retrieved on: 19th December, 2018.
- Foo, L. H. Zhang, Q. Zhu, K. Ma, G. Greenfield, H. and Fraser, D. R. Influence of Body Composition, Muscle Strength, Diet and Physical Activity on Total Body and Forearm Bone Mass in Chinese Adolescent Girls. *The British Journal of Nutrition*, 2007, 98(6): 1281-1287; Citation from: https://www.ncbi.nlm.nih.gov /pmc/articles/PMC3588620/; Retrieved on: 18th February, 2019.
- Gryko, K. Kopiczko, A. Mikolajec, K. Stasny, P. and Musalek, M. Anthropometric Variables and Somatotype of Young and Professional Male Basketball Players.*Sports*, 2018, 6(9): 1-10; Citation from: www.mdpi.com/2075-4663/6/1/9 /pdf; Retrieved on: 16th December, 2018.
- Hager-Ross, C. and Schieber, M. H. Quantifying the Independence of Human Finger Movements: Comparisons of Digits, Hands, and Movement Frequencies. *Journal of Neurosciences*, 2000, 20(22): 8542-8550; Citation from: https://www. ncbi.nlm.nih.gov/pmc/articles/PMC3588620/; Retrieved on: 19th December, 2018.
- http://www.topendsports.com/testing/tests/handgrip.htm
- https://howtheyplay.com/misc/The-Advantages-of-Long-Arms-in-Sports
- https://livehealthy.chron.com/hand-size-affect-shooting-ball-3415.html
- https://www. topendsports.com/testing/tests/arm-span.htm
- https://www.wikihow.com/Measure-Hand-Size
- Hurbob, J. and Jurimaea, T. Relationship of Handgrip Strength with Anthropometric and Body Composition Variables in Prepubertal Children. *Homo*, 2009, 30(3): 225-238; Citation from: https://www.sciencedirect.com/science/ article/pii/S0018442X08000589; Retrieved on: 20th February, 2019.

- Indoria, A. & Singh, N. Role of Nutrition in Sports: A Review. *Indian Journal of Nutrition*, 2016, 3 (2): 1-6. Citation from: http://www.opensciencepublications. com/wp-content/uploads/IJN-2395-2326-3-147.pdf; Retrieved on: 17th January, 2019.
- Jurimae, T. and Visnapuu, M. Handgrip Strength and Hand Dimensions in Young Handball and Basketball Players. *Journal of Strength & Conditioning Research*, 2007, 21(3): 923-929; Citation from: http://www.ncbi.nlm.nih.gov/pubmed/ 17685672; Retrieved on: 15th February, 2019.
- Kamarul, T., Ahmad, T.S., & Loh, W.Y. Hand grip strength in the adult Malaysian population. Journal of Orthopaedic Surgery, 2006, 14(2), 172-177.
- Koley, S. H., Kaur, S. P., & Sandhu, J. S. Association of hand grip strength with some anthropometric traits in collegiate population of Amritsar. Anthropologist, 2009, 11(3), 231-238.
- Koley, S. Singh, J. and Kaur, S. A Study of Arm Anthropometric Profile in Indian Inter-University Basketball Players. *Serbian Journal of Sports Sciences*, 2011, 5 (1): 35-40; Citation from: http://sjss-sportsacademy.edu.rs/archive/details/a-study-of-arm-anthropometric-profile-in-indian-inter-university-; Retrieved on: 22nd February, 2019.
- Longvah, T. Ananathan, R. Bhaskarachary, K. & Venkaiah, K. Indian Food Composition Tables. National Institute of Nutrition (Indian Council of Medical Research), Department of Health Research, Ministry of Health & Family Welfare, Government of India, Hyderabad, Telangana State, India, 2017, 1-578.
- López-Bueno, R., Andersen, L. L., Calatayud, J., Casajús, J. A., Smith, L., & López-Sánchez, G. F. Association between hand grip strength and depressive symptoms among 35,618 Spanish adults. Journal of Affective Disorders, 2020, 263, 310-315.
- Nag, A. Nag, P. K. and Desai, H. Hand Anthropometry of Indian Women. *Indian Journal of Medical Research*, 2003, 117: 260-269; Citation from: http://www.johk.pl/files/16a.pdf; Retrieved on: 20th December 2018.
- Nande, P. J. & Vali, S. A. Fitness Evaluation Tests for Competitive Sports, Himalaya Publication, First Edition, 2010, 1-257.
- Nande, P. Mudafale, V. and Vali, S. A. Study on Energy Balance among Female & Male Players Engaged in Different Sports Disciplines. *Journal of Exercise Science and Physiotherapy*, 2008, 4(1): 1-14; Citation from: http://medind.nic.in/jau/ t08/i1/jaut08i1p1.pdf; Retrieved on: 18th January, 2019.
- National Institute of Nutrition (NIN)/Indian Council of Medical Research (ICMR). Nutrient Requirements & Recommended Dietary Allowances for Indians. A Report of the Expert Group of the Indian Council of Medical Research (ICMR), National Institute of Nutrition (NIN), Hyderabad, 2009.
- Nicolay, C. W. and Walker, A. L. Grip Strength and Endurance: Influence of Anthropometric Variation, Hand Dimension and Gender. *International Journal of Industrial Ergonomics*, 2005, 35: 605-618; Citation from: https://www.ncbi.nlm. nih.gov/pmc/articles/PMC3588620/; Retrieved on: 18th February, 2019.
- Osterberg, K. Fueling the Basketball Athlete: The Practitioner's Approach. Nutrition & Recovery Needs of the Basketball Athlete a Report from the 2013 GSSI Basketball Taskforce, 2017: 42-48; Citation from: https://www.gssiweb .org/docs/default-

source/default-document-library/bball-task-force-final88EF51B 080A9.pdf?sfvrsn=2; Retrieved on:15th December, 2018.

- Ozturk, A. Cicek, B. Mazicioglu, M. Zararsiz, G. and Kurtoglu, S. Wrist Circumference and Frame Size Percentiles in 6-17-year old Turkish Children and Adolescents in Kayseri. *Journal of Clinical Research in Pediatric Endocrinology*, 2017, 9(4): 329-336; Citation from: https://www.researchgate.net/publication/317015630_Wrist_Circumference_And_Frame_Size_Percentiles_In_6-17 year_Old_Turkish_Children_And_Adolescents_In_Kayseri; Retrieved on 24th December, 2018.
- Pheasant, S. Bodyspace: Anthropometry, Ergonomics and the Design of Work (2nd ed.). Taylor & Francis, 1996.
- Pizzigalli, L. Micheletti Cremasco, M. L. A. Torre, A. Rainoldi, A. and Benis, R. Hand Grip Strength and Anthropometric Characteristics in Italian Female National Basketball Teams. *Journal of Sports Medicine and Physical Fitness*, 2017, 57(5): 521-528; Citation from: http://www.ncbi.nlm.nih.gov/pubmed/26959872;Retrieved on: 18th December, 2018.
- Prista, A., Marques, A. T., & Maia, J. A. Anthropometric characteristics of young male athletes and nonathletes. Revista Portuguesa de Ciências do Desporto, 2003, 3(3), 279-285.
- Richards, L. Olson, B. & Palmiter-Thomas, P. How Forearm Position Affects Grip Strength. *The American Journal of Occupational Therapy*, 1996, 50: 133-139; Citation from: http://www.iosrjournals.org/iosr-jdms/papers/Vol16-issue7/Version-4/O1607046265.pdf; Retrieved on: 14th February, 2019.
- Rowland, T. W. Black, S. A. and Kelleher, J. F. Iron Deficiency in Adolescent Endurance Athletes.*Journal of Adolescent Health Care,*1987, 8(4): 322–326; Citation from: https://www.jahonline.org/article/0197-0070(87)90002-7/abstract; Retrieved on:5th September, 2018.
- Scheuer, L. Black, S. and Schaefer, M. C. Junevile Osteology: a Laboratory and Field Manual, Ed: Elsevier Inc., 2009.
- Sevinc, D. & Yilmaz, V. The Relationship between Anthropometric Properties and Physical Performance Levels of 9-12 Years Old Taekwondoists. *International Journal of Science Culture and Sport*, 2017, 5(4): 285-292; Citation from: http://www.iscsjournal.com/Makaleler/789255731_5c4s_4.pdf; Retrieved on: 20th February, 2019.
- Singh, K. and Ram, M. Kinanthropometric Profile as a Predictor of Basketball Players Strength Measures. *International Journal of Innovative Research & Development*, 2013, 2(8): 355-360; Citation from: http://www.ijird.com/index.php/ijird/article/viewFile/36497/29473; Retrieved on: 11th December, 2018.
- Tsakalou, L. Kotsampouikidou, Z. Papa, M. and Zapartidis, I. Handgrip Strength and Ball Velocity of Young Male and Female Handball Players. *Journal of Physical Education and Sport*, 2015, 15(4): 800-804; Citation from: https://efsupit.ro/images/stories/nr4.2015/Art122.pdf; Retrieved on: 19th December, 2018.

- Visnapuu, M. and Jurimae, T. Handgrip Strength and Hand Dimensions in Young Handball and Basketball Players. *Journal of Strength and Conditioning Research*, 2007, 21(3): 923-929; Citation from: https://journals.lww.com/nsca-jscr/Abstract/2007/08000/HANDGRIP_STRENGTH_AND_HAND_DIMENSIONS_IN_YOUNG.45.aspx; Retrieved on: 19th August, 2018.
- Wagh, P. D. Birajdar, G. and Nagavekar, M. Comparison of Handgrip Muscle Strength in Sportsmen and Sedentary Group. *IOSR Journal of Dental and Medical Sciences*, 2017, 16(7): 62-65; Citation from: http://www.iosrjournals.org/iosr-jdms/papers/Vol16-issue7/Version-4/O1607046265.pdf; Retrieved on: 15th February, 2019.
- Zapartidis, I. Nikolaidou, M. E. Vareltzis, I. and Kororos, P. Sex Differences in the Motor Abilities of Young Male and Female Handball Players.*Biology of Sport*, 2011, 28, 171-176; Citation from: https://efsupit.ro/images/stories/nr4.2015 /Art122.pdf; Retrieved on: 19th December, 2018.