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Relationship of anthropometric measurement and handgrip strength in Malaysian recreational tenpin bowlers

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Abstract

Background and Study Aim Established studies show that athletes with longer fingers and broader hand surfaces have more muscular grips. Therefore, some research studies have examined various contributing factors and anthropometric characteristics. Thus, the aim of this study was to investigate the effect of hand dimensions and selected anthropometric characteristics on handgrip strength in recreational tenpin bowlers.

Material and Methods This cross-sectional study recruited 32 (12 females, 20 males) healthy Malaysian recreational tenpin bowlers from Kuala Lumpur. Their anthropometric characteristics including height, weight, body mass index (BMI), the dimensions of the right hand, and age were measured accordingly. Handgrip strength was assessed using a Takei 5401 Grip D (Digital Grip Dynamometer) with 3 trials for both hands. A Pearson correlation coefficient and multiple regression analysis were used to study the relationship between the parameters.

Results The body height and the minimum breadth of the right hand had a significant impact on handgrip strength among recreational tenpin bowlers. There was a significant difference between males and females in left and right handgrip strength ($p<0.05$). Males showed a greater handgrip strength compared to females in both hands' strength. Body height ($p = 0.00$) and the minimum breadth of the hand ($p = 0.03$) were found to be significantly correlated with the handgrip strength thus indicating the two variables as strong predictors of handgrip strength.

Conclusions This study confirms that there is a relationship between anthropometric characteristics and handgrip strength in Malaysian recreational tenpin bowlers. Hence, it will be a great note for new bowlers to advance their bowling performance.

Keywords: handgrip strength, tenpin bowling, anthropometry, hand dimensions, dynamometer

Introduction

Tenpin bowling is a widely known sport and is played at a professional level and as a recreational activity by the general public. In 2018 it was s reported that 4.45% of Malaysian played tenpin bowling [1]. The aim of this sport is needed a bowler to roll down the bowling ball onto the lane and knock down the pins at the edge of the bowling lane as many as the bowler can during an event. Accumulated pinfalls would determine the winner.

3 major essential roles that contribute to the performance are a bowler, a bowling ball, and a bowling lane. A fingertip grip is one of a skill that a bowler could bowl with a hook style [2]. The middle, ring, and thumb finger are inserted into designated holes with specific lengths and depths. Meanwhile, the remaining fingers and another dimension of playing hands will support carrying a bowling ball during the approach and delivery phases. This requires a configuration of the bowler's hand dimensions and grip measurement that will be mapped and hence, drilled on a bowling ball [3]. The palm and forearm include the muscles that move the finger joints [4]. The forearm muscles are crucial for the upper limb's fine motor activities, enabling intricate motions of the arm, wrist, and fingers [5]. The wrist joint, also known as the radiocarpal joint, is a distal upper limb condyloid synovial joint that links and acts as a transition between the forearm and hand. A condyloid joint is a type of modified ball and socket joint that enables flexion, extension, abduction, and adduction motions [6]. Therefore, stronger forearms lead to a stronger grip [7].

Handgrip strength (HGS) can be a popular indicator of muscle strength in tenpin bowlers as it became a tool to investigate and determine the muscular force in humans. Many methods have been found to measure handgrip strength, such as using an analogy or digital dynamometer [8]. A study has found that elite bowlers were heavier, had longer lower leg and hand lengths, and had wider arm spans as compared to non-bowlers [9]. The study also explained that elite bowlers had stronger forearm or wrist rotation and arm flexion [10]. The importance of anthropometrics measurement was suggested that coaches would benefit by selecting larger-built bowlers with long limbs for their tenpin bowling

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teams [9]. Although the differences in body types between men and women, sedentary and athletes caused the variations in their muscular strength [11], the relationship between hand dimensions, anthropometry characteristics, and HGS are still vague among recreation bowlers.

Thus, this present study was conducted to determine whether age, weight, height, body mass index (BMI) and hand dimensions were predictive of handgrip strength, specifically in recreational tenpin bowlers.

Materials and Methods

Participants

Thirty-two (12 female, 20 male) healthy recreational tenpin bowlers from the Endah Parade Bowling Centre, Kuala Lumpur (Malaysia) participated in this cross-sectional descriptive study. All 32 subjects had a mean ± SD age of 33.81 ± 7.82 years. They were all right-hand dominant.

Research Design

A descriptive cross-sectional study was used in this study. Data collection was conducted at the Endah Parade Bowling Centre as well. The inclusion criteria were as follows: (i) Free from any illness and injuries at the time of the study, (ii) have a minimum 5 years of experience in tenpin bowling, (iii) have a hook playing pattern. Meanwhile, the exclusion criteria were as follows: (i) have a straight playing pattern, (ii) aged below 18 years old. This study received ethical approval from the University of Malaya Research Ethics Committee (reference number UM.TNC2/UMREC – 962). All subjects gave their written informed consent after being provided with the description of the study.

Anthropometric. Age was recorded for each subject. The body weight and body height were measured using a standard digital weighing scale and a standard height scale and the BMI was calculated. The hand dimensions were measured using a flexible tailor tape between the midpoints of the distal transverse of the wrist to the anterior projection of the middle finger. The handbreadth was then measured from the lateral points of the head of the index finger to the medial point of the little finger. Meanwhile, the maximum handbreadth was measured from the lateral point of the thumb to the medial point of the little finger. The palm length was measured from the middle of the inter stylion to the proximal of the middle finger. The thumb length as well being measured from the distance from the tip of the thumb to the crease with the palm. For the index finger length, the measurement was collected from the tip of the index finger to the border crease with the palm. The middle finger length was measured from the distance of the tip of the middle finger to the border crease with the palm. Meanwhile, the ring finger length was measured from the tip of the ring finger to the border crease with the palm unliked the little finger length measured from the tip of the little finger to the border crease with the palm.

The hand measurements were collected on the right hand of the participants. In this study, all the participants are right-hand dominant. The right hand was measured with the hand on a flat horizontal surface with the thumb in an abducted position and the other fingers in an extended position (see Fig. 1.) Anthropometric measurements were repeated three times.

Handgrip Measurement. Subjects were given

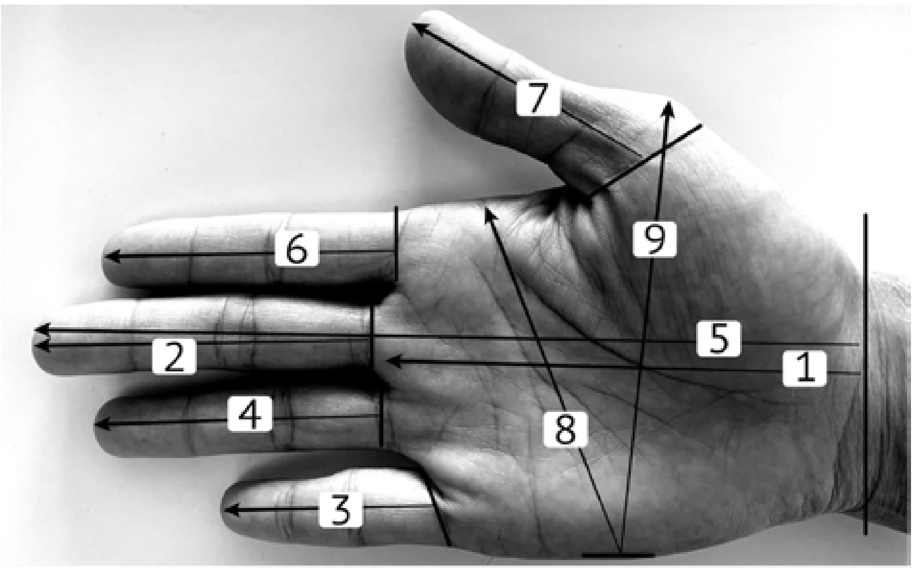

Figure 1. Hand dimensions (Hand anthropometric (1-palm length, 2-middle finger length, 3- little finger length, 4- ring finger length, 5-hand length, 6- index finger length, 7- thumb finger length, 8- minimum handbreadth, 9- maximum handbreadth)

a demonstration and underwent five minutes of familiarization with the Takei 5401 Grip D (Digital Grip Dynamometer) made in Japan. Prior to data collection, subjects were instructed to stand comfortably with their left hand resting whilst their right hand was holding the dynamometer over their head. Subjects were advised to maximally squeeze alongside shoulder adduction with elbow extension at 90° for three seconds. The step was repeated with the left hand and thus considered as one set of measurements. Measurements were taken for three sets with one minute of rest in between sets (see Fig. 2.).

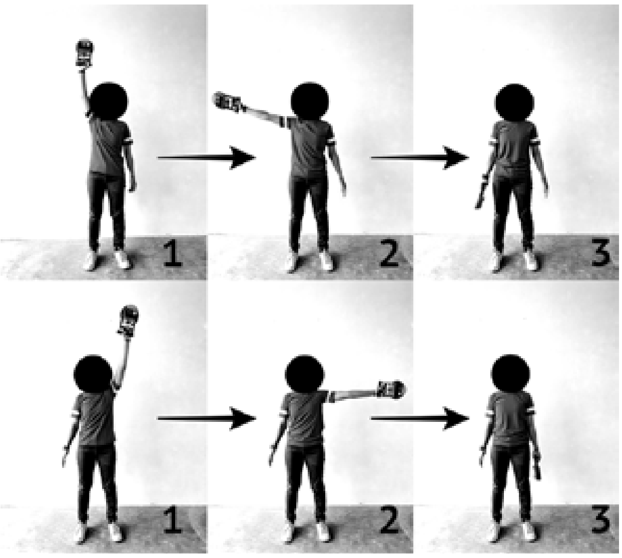

Figure 2. Steps for measuring handgrip strength

Statistical Analysis

All data were analyzed using one-way analysis of variance (ANOVA). The data were expressed as mean ± standard deviation. Differences between the groups were evaluated by LSD post hoc test and considered significant at $p<0.05$. Correlation and multiple regression analysis were conducted to see a relationship between hand dimensions, anthropometrical, and handgrip strength.

Results

The anthropometric measurements are presented in Table 1. Table 2 showed that there was a significant difference between males and females in left and right handgrip strength ($p<0.05$). Males showed a greater handgrip strength compared to females in both hands' strength. A Pearson correlation coefficient matrix was carried out to determine the relationship between the body weight, body height, BMI, age, right-hand dimensions (palm span, hand length, thumb finger, index finger, middle finger, ring finger, minimum and maximum breadth) and the right handgrip strength (RHGS) are presented in Table 3. There was a strong, positive correlation between body height and RHGS ($r = 0.71$, $n = 32$, $p = 0.00$), palm span and RHGS ($r = 0.52$, $n = 32$, $p = 0.00$), hand length and RHGS ($r = 0.565$, $n = 32$, $p = 0.00$), middle finger and RHGS ($r = 0.43$, $n = 32$, $p = 0.01$), ring finger and RHGS ($r = 0.45$, $n = 32$, $p = 0.01$), minimum breadth and RHGS ($r = 0.59$, $n = 32$, $p = .00$) and maximum breadth and RHGS ($r = .44$, $n = 32$, $p = 0.01$). The multiple stepwise regression model with thirteen predictors was conducted and it showed that the body height ($p = 0.00$) and the minimum breadth of the hand ($p = 0.03$) were found to be significantly correlated with the handgrip strength thus indicating the two variables as strong predictors of handgrip strength (Table 4). The model with two predictors produced $R = .758$, $F(2, 29) = 19.59$, $p < 0.05$, and accounted for 58% of the variation in handgrip strength.

Table 1. Anthropometric characteristics for healthy recreational tenpin bowlers to determine the relationship between anthropometric measurements and dimension of the right hand (n = 32)

Variables[a]	Mean ± SD
Age	33.81 ± 7.82
Height	1.66 ± 0.08
Weight	67.81 ± 14.25
BMI	24.49 ± 4.94
Palm Span	18.58 ± 1.42
Half Span	10.76 ± 0.83
Thumb	6.62 ± 0.52
Index	7.33 ± 0.48
Middle	7.88 ± 1.00
Ring	7.30 ± 0.57
Little	6.00 ± 0.48
Min Breadth	8.38 ± 0.79
Max Breadth	10.46 ± 1.14
Handgrip Strength (kg)	29.60 ± 7.65

[a] Data are presented as mean ± SD.

Discussion

This study aimed to determine whether age, BMI, body weight, body height, and hand dimensions were predictive of handgrip strength in recreational tenpin bowlers. Tenpin bowling sport consists of five steps of approaches in delivering a bowling ball onto the lane to knock down the ten pins while engaging the upper and lower limbs of a tenpin bowler including shoulder flexion, trunk rotation, hip, and knee flexions [9, 12, 13].

The results of this study showed that strong handgrip strength is determined by the stature of

Table 2. Handgrip strength performance in recreational tenpin bowlers

Parameters	Females	Males	P value
	Mean ± SD (kg)	**Mean ± SD (kg)**	
Left handgrip strength	21.51 ± 3.52	33.19 ± 5.35	0.00*
Right handgrip strength	23.05 ± 3.44	34.79 ± 5.69	0.00*

* Significant at the 0.05 level (2-tailed).

Table 3. Pearson correlation coefficient matrix for anthropometric characteristics and handgrip strength in recreational tenpin bowlers

	BW	**BH**	**BMI**	**PS**	**HL**	**TH**	**IN**	**MI**	**RI**	**LI**	**MB**	**MX**	**AG**	**HS**
BW		0.03*	0.00*	0.07	0.12	0.24	0.7	0.00*	0.35	0.31	0.84	0.04	0.68	0.13
BH	0.03*		0.71	0.00*	0.00*	0.04	0.01*	0.01*	0.01*	0.28	0.00*	0.01*	0.43	0.00*
BMI	0.00*	0.71		0.62	0.85	0.83	0.37	0.09	0.75	0.07	0.25	0.39	0.38	0.82
PS	0.07	0.00*	0.62		0.00*	0.00*	0.00*	0.00*	0.00*	0.04*	0.00*	0.00*	0.32	0.00*
HL	0.12	0.00*	0.85	0.00*		0.00*	0.00*	0.00*	0.00*	0.02*	0.00*	0.00*	0.44	0.00*
TH	0.24	0.04*	0.83	0.00*	0.00*		0.00*	0.02*	0.00*	0.01*	0.01*	0.01*	0.02*	0.1
IN	0.7	0.01*	0.37	0.00*	0.00*	0.00*		0.1	0.00*	0.00*	0.00*	0.02*	0.28	0.14
MI	0.00*	0.01*	0.09	0.00*	0.00*	0.02*	0.1		0.00*	0.29	0.13	0.13	0.65	0.01*
RI	0.35	0.01	0.75	0.00*	0.00*	0.00*	0.00*	0.00*		0.03	0.00*	0.00*	0.65	0.01*
LI	0.31	0.28	0.07	0.04*	0.02*	0.01*	0.00*	0.29	0.03*		0.00*	0.07	0.09	0.48
MB	0.84	0.00*	0.25	0.00*	0.00*	0.01*	0.00*	0.13	0.00*	0.00*		0.00*	0.36	0.00*
MX	0.04*	0.01*	0.39	0.00*	0.00*	0.01*	0.02*	0.13	0.00*	0.07	0.00*		0.76	0.01*
AG	0.68	0.43	0.38	0.32	0.44	0.02*	0.28	0.65	0.65	0.09	0.36	0.76		0.79
HS	0.13	0.00*	0.82	0.00*	0.00*	0.1	0.14	0.01*	0.01*	0.48	0.00*	0.01*	0.79	

* Correlation is significant at the 0.05 level (2-tailed). BW - body weight; BH - body height; BMI - body mass index PS - palm span; HL - hand length; TH - thumb; IN - index; MI - middle; RI - ring; LI - little; MB - minimum breadth; MX - maximum breadth; AG - age; HS - handgrip strength

height and hand dimension (minimum breadth) in recreational tenpin bowlers. To the best of our knowledge, this study is the only one to report the predictive relationships between standing handgrip strength and the anthropometric measures in recreational tenpin bowlers. This study also provides evidence that hand dimensions can influence handgrip strength, which might have an impact on force-velocity relationships.

Along the movement and approaches, a bowler would carry a heavy bowling ball to knock down the pins as much as possible by generating a lot of momentum using these heavy bowling balls and releasing them accurately [14]. When the joint torques of the torso and the arm moved together, it indicated that the bowling ball was in a push-like motion [15]. The study also agreed that bowlers used the steps to increase the linear velocity, simple pendulum, and torques in the torso and the arm to enhance the power at the release of the bowl.

As the amount of maximum force transmits from every approach; lower and upper limbs, it explains that a bowler needs great strength to play this sport [16]. Thus, muscle strength is defined by a larger muscle girth with a larger cross-sectional area, hence generating a greater force [17]. The forceful flexion of the thumbs, finger joints and wrist with the maximum voluntary force leads to handgrip strength [18].

Therefore, handgrip strength is a predictor of physical fitness, hand functions, and nutritional status to measure strength in recreational tenpin bowlers. According to that, there are many factors that may contribute including gender, age, body mass index, and even hand dimensions [19]. Interestingly, anthropometry can be a major contributor to successful performance in sports. A significant relationship was found between height, leg length, shoulder width, and hip width in long jumpers in long jump performance sports [20].

A bowler supports the bowling ball with hands during the addressing phase, holding, gripping and swinging from the second phase until the final approach. Each swing is executed at a speed that generates a high ball momentum [10]. The study also stated that arm flexors contribute to the

Table 4. Multiple regression analysis for anthropometric characteristics and handgrip strength in recreational tenpin bowlers (n=32).

Coefficients[a]								
	Standardized Coefficients	t	Sig.	R	R Square	Adjusted R Square	df	F
	Beta							
(Constant)								
AG	0.19	-1.55	0.13	0.76	0.58	0.55	regression=2, residual=29	19.59
BW	0.06	0.41	0.69					
BH	0.55	3.92	0.00*					
BMI	0.07	0.52	0.61					
PS	0.05	0.28	0.78					
HL	0.15	0.89	0.38					
TH	-0.07	-0.52	0.61					
IN	-0.21	-1.43	0.16					
MI	0.11	0.8	0.43					
RI	-0.06	-0.35	0.73					
LI	-0.19	-1.37	0.18					
MB	0.32	2.26	0.03*					
MXB	-0.05	-0.28	0.78					

[a] Dependent Variable: RHGS. BW - body weight; BH - body height; BMI - body mass index PS - palm span; HL - hand length; TH - thumb; IN - index; MI - middle; RI - ring; LI - little; MB - minimum breadth; MX - maximum breadth; AG - age; HS - handgrip strength. * Significant at the 0.05 level (2-tailed).

forward motion of the forearm in the final phase of the swing. As follows, strength is required to assist the deliveries.

Release parameters is determining the measured distance of the throw [21]. Wrist torque and kinematics were also found to be most associated with speed [22, 23]. This explains why wrist torque is important as the wrist rotates to deliver a bowling ball in the final phase of the approach [24]. Hence, release velocity is a crucial factor in determining the distance of a throw whereas the bowling ball will be thrown and glide onto the bowling lane [25]. The differences in delivery and release on wrist rotation over the different weights of bowling balls onto bowling lanes can be investigated in future studies as the trajectory was generated from the wrist motion [26].

In this study, the handgrip strength was higher in males compared with female recreational tenpin bowlers. Male has greater strength as male has a greater mass that may generate larger forces. This is in agreement with several past studies that stated the gender factor can be the most significant predictor of handgrip strength [19, 27, 28].

A Pearson correlation coefficient matrix for body height, palm span, hand length, middle finger, ring finger, minimum breadth, maximum breadth, and handgrip strength showed strong correlations with each other. Meanwhile the body height and the minimum breadth of the hand) were found to be significantly correlated in the multiple regression model analysis. In accordance with the present results, previous studies have demonstrated that height [29, 30, 31], BMI [32, 33, 34] and the length and dimensions of the forearm, arm, and hands were significantly correlated with handgrip strength [35, 36, 37].

A greater height will lead to a long arm as the shoulder be the axis of the long arm and it will generate a greater force [19]. As the shoulder acted as an axis and rotated during the approaches, the length of the shoulder is crucial as it depends on the distribution of the mass relative to the axis of the rotation [38]. This element may explain the relatively good correlation between anthropometry and pattern of entries (pocket entry board position, pocket entry speed, and pocket entry angle) in pinfalls.

It was reported earlier that physical performance had a strong association with the body strength, shape, size, form, and structure of an individual [39]. As a larger hand size may have higher strength due to a larger muscle area, smaller hands may contribute to weaker handgrip strength due to the muscle area involved [32, 40]. A dominant hand may influence the handgrip's strength as much as hand circumference does [41]. A study also supported that elite and semi-elite tenpin bowlers' results showed significantly longer upper limbs than non-tenpin bowlers. It is proven that anthropometry may influence muscular strength in recreational tenpin bowlers as well [10].

Body height can be a general factor that affects all body dimensions. When a player has a greater segment, the player has the advantage of throwing the ball at a higher speed, which increases the rotation radius, thus causing a proportional increase of the torque and consequently an increase in the linear velocity [42]. Therefore, considering this information, recreational tenpin bowlers should be conscious of the importance of handgrip strength and body dimensions to avoid injuries and increase performance [43].

Handgrip strength is important to enhance the performance of several gross motor movement patterns in sports and athletic disciplines involving the hand. Thus, to improve one's strength the study suggested increasing upper and lower body strength is increasing muscle mass through resistance training interventions. This can be done by looking at some factors that can be implemented in sport-specific movement such as technical ability; (coordination, sequencing, timing, physical ability; strength, flexibility, neuromuscular function, body composition anthropometry), and tactical ability [43].

Conclusions

The aim of this study was to confirm the relationship between anthropometric characteristics and handgrip strength in recreational tenpin bowlers. The present results demonstrated that basic anthropometric characteristics (body height and hand dimension – minimum breadth) have a strong relationship with handgrip strength among recreational tenpin bowlers.

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Conflict of interest

The authors declare no conflict of interest, financial or otherwise.

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