HAND GRIP STRENGTH, BODY MASS INDEX AND ANTHROPOMETRIC MEASUREMENTS AMONG FEMALE UNIVERSITY STUDENTS: PRELIMINARY DATA IN BAHRAIN

DALIA M KAMEL[*1,2]

FATIMA E MIRZA[1]

FATIMA H AL-ZAKI[1]

JENAN J AL-SEHALI[1]

ZAHRA A ABDULLA[1]

[1]Physical Therapy Department
College of Medical & Health Sciences
Ahlia University
Kingdom of Bahrain
Email: dshewitta@ahlia.edu.bh

[2]Physical Therapy for Women's Health
Faculty of Physical Therapy
Cairo University
Egypt

*Corresponding Author

ABSTRACT

Background: The hand forms the most sophisticated musculoskeletal tool in the human body. Its strength as measured by a hand grip dynamometer gives us much information about the body's systems and human habits. It is affected by several factors, including the Body Mass Index (BMI), total arm length, Mid Upper Arm Circumference (MUAC), hand dominance, gender and the level of physical activity.

Purpose of the study: To have a database about hand grip strength and other factors that may affect it among Bahraini university students. This can be used to set individualised goals for adults with impaired muscular strength although otherwise healthy.

Methodology: A total of 77 female students from Ahlia University in Bahrain were included in the study. They completed a demographic data sheet and some anthropometric variables were measured.

Results: there were significant correlations ($P < 0.05$) in hand dominance, body mass index, and lifestyle hand grip strength. However, there was no significant correlations ($P > 0.05$) regarding handedness, keyboard usage hours, practicing skilful hand hobbies with the hand grip strength.

Conclusion: The factors that show a significant relationship together with hand grip strength should be taken into consideration when aiming to improve the hand grip strength for any individual, whether they are healthy or have any impairment.

Practical Implications: Predict the normal hand grip strength among female Bahraini youth.

***Keywords*:** body mass index; mid upper arm circumference; hand grip strength; total arm length; hydraulic dynamometer; handedness; life style

INTRODUCTION

The hand represents the most complex tool in the human body, requiring the largest capacity of the nervous system in relation to its size (Angst et al., 2010). The characteristic structure of the hand is related to its function as a grasping tool. There are 35 muscles required for movement of the hand and forearm, with many of these involved in gripping activities. During gripping activities, the muscles of the flexor mechanism in the hand and forearm create the grip strength, while the extensors of the forearm stabilise the wrist (Weinick, 1990). The power of a hand grip is the result of forceful flexion of all finger joints, as well as by the fact that the thumb can be opposed to the fingers, with the maximum voluntary force that the subject is able to function under normal bio-kinetic conditions (Koley and Singh, 2010).

When powerful movements of the fingers are required, both the flexors and extensors of the wrist contract simultaneously. The effectiveness of these actions is evident when attempts are made to grip strongly with the finger flexors when the wrist is already flexed; extending the wrist stretches these muscles and they can exert a considerable amount of power. A slight degree of extension of the wrist is the position naturally adopted when the hand is used for gripping (Palastanga et al., 2006). The hand grip strength test is a simple and economic test that measures the muscular strength of an individual, and gives practical information about muscle, nerve, bone or joint disorders (Ruiz et al., 2006).

The measure of hand grip strength is affected by several factors including age, gender, different angle of shoulder, elbow, forearm and wrist, posture, grip span, and

hand span (Ruiz et al., 2006), in addition to hand dominance, occupation, weight, and height (Kamarul et al., 2006). Furthermore, other factors affecting hand grip strength are hand length, life style, hand breadth, upper arm length, forearm length, total arm length, arm circumferences and various subcutaneous skin folds (Koley et al., 2009).

Although all these factors play a role in the hand grip strength, the BMI remained a significant contributor to the variation in hand grip strength (Pieterse et al., 2002).

BMI is correlated strongly with body fat percentage and it correctly detects the fattest individuals (Artero et al., 2009). It is also an indicator of muscle mass and fat mass (Pieterse et al., 2002). This is why an adult with low BMI shows a decrease in fat mass with lean body mass including muscle; in turn this indicates a reduction in body energy stores (Vas et al., 1996).

The effect of low physical activity among the overweight and obese, leads to lower muscle strength (Hulens et al., 2001). Thus it lowers hand grip strength as this is directly related to overall muscle strength (Costa et al., 2010). On the other hand, specific histological and metabolic characteristics of the muscles among obese individuals, can demonstrate an increase in lean mass and a more powerful muscle contraction (Costa et al., 2010). Moreover, adults with low BMI manifest a decrease in fat mass as well as lean body mass, including muscles (Vas et al., 1996), which affect the grip strength. There is a strong correlation between grip strength and overall upper body strength. The effect of elbow position on grip strength is found to be higher with the elbow flexed at 90^{o} (Dhara et al., 2009).

Based on the aforementioned literature, the aim of this study was to have a hand grip reference values among college age female students, and highlight the factors that may affect their grip strength.

METHODOLOGY

Subjects

A total of 77 female Bahraini students were recruited in this study through posts distributed in the university to encourage students to participate. Their ages varied between 18 and 25 years old. Exclusion criteria were using both hands in writing, current pregnancy, sickle cell disease, recent injuries or operations on the hands, or complaints of any other physical disability.

Procedure

The subjects were asked first to sign a consent form and complete a self-developed questionnaire; this was available in both English and Arabic versions. Its purpose was

to gather demographic data about our subjects regarding their lifestyle and specifically about the pattern of using the hands in daily activity.

After completing the questionnaire, the following measurements were taken for each subject:

1) Weight and height measurement according to the guidelines of the Center for Disease Control (Center for Disease Control, 2007);
2) Total Arm length (TAL) was measured from the tip of the acromion process to the end of the ulnar styloid process, while the arm was at the side of the body. This procedure was performed for both upper limbs (Haboubi et al., 1990);
3) Mid Upper Arm Circumference (MUAC) is the circumference measurement at the point which is the midway between the acromion process to the tip of olecranon process (Center for Disease Control, 2007);
4) Hand grip strength, using hydraulic hand dynamometer (SH5001 SAEHAN Corporation, Korea) while the subject was seated on a 90° angled chair, back supported, and both feet placed on the ground. The examiner instructed the subjects to adduct their shoulders and hold the hydraulic dynamometer in the dominant hand first, placing the elbow at a 90° flexed position and grip as hard as possible on the device. By careful observation, the examiner made sure that the wrist was extended to 30° with ulnar deviation to 15° while performing the test (Richards and Palmiter, 1996).

The outcome measures were BMI, total arm length, MUAC, gender, and lifestyle, on the hand grip strength of the dominant and non-dominant hands. All the obtained data was tabulated and inserted into the SPSS 14.0 for Windows Integrated Student Version (SPSS (Statistical Package for the Social Science) Inc., Chicago, IL, USA) for statistical analysis via an unpaired t-test, Analysis of Variance (ANOVA), and correlation. The level of significance was selected at the 5% level.

RESULTS

The hand grip strength, BMI and the upper limb selected anthropometric measurements are presented in Table 1.

The dominant hand grip mean value was 22.22kg (±4.78), which was higher than the non-dominant hand grip that was 18.99kg. According to hand dominance, there was significant difference ($P = 0.0001$) in hand grip strength.

Regarding the BMI, the mean value was 24.60kg/m^2 (±6.03). The majority had a normal BMI (46, 59.7%), while the lowest number was morbidly obese (2, 2.59%). All other BMI categories are presented in Figure 1. There was significant correlation between different BMI and hand grip strength for the dominant hand ($r = 0.27$, $P = 0.017$), while there was no significant correlation for the non-dominant hand ($r = 0.19$, $P = 0.103$).

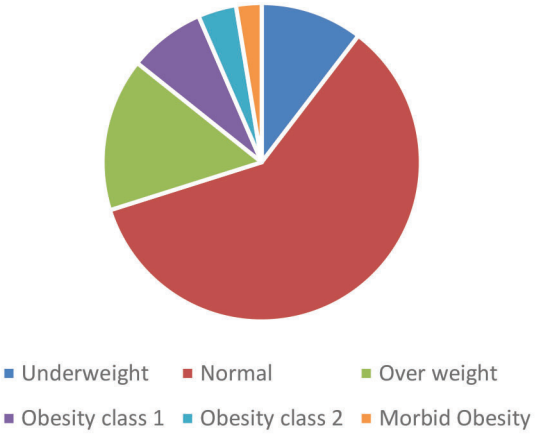

Figure 1 Different Classification of BMI among Participants

Source: Devised by authors

Table 1 BMI, Hand Grip Strength, MUAC and TAL in Female Subjects

	Mean (SD)	Minimum	Maximum
BMI	24.09 (6.01)	15.60	47.90
DMUAC	27.10 (5)	20.00	45.00
NDMUAC	27.10 (4.9)	19.50	44.00
DTAL	54.72 (2.3)	49.00	61.00
NDTAL	54.37 (2.2)	49.00	62.00
D grip	22.22 (4.7)	12.00	36.00
ND grip	18.98 (4.3)	10.00	28.00

Notes: BMI - body mass index; DMUAC - dominant mid upper arm circumference; NDMUAC - non-dominant mid upper arm circumference; DTAL - dominant total arm length; NDTAL - non-dominant total arm length; D grip - dominant grip; ND grip - non-dominant grip.

Source: Devised by authors

The Total Arm Length (TAL) mean value was 54.72cm (2.3) for the dominant hand, while the non-dominant TAL mean value was 54.37cm (2.2). There was a positive significant correlation between the dominant and the non-dominant hand grip strength and TAL, $r = 0.249$ ($P = 0.003$) in dominant, and non-dominant $r = 0.225$ ($P = 0.049$).

In addition, the MUAC mean value in the dominant hand was 27.10cm (5); for the non-dominant hand, the MUAC mean value was 27.10cm (4.9). There was a highly significant correlation for the dominant hand ($r = 0.255$ & $P = 0.02$), while there was no significant correlation for the non-dominant hand ($r = 0.194$ & $P = 0.09$).

For the keyboard usage time, 27 (35.06%) subjects used the keyboard for less than 3 hours per day; 28 (36.4%) and 8 (10.4%) subjects used the keyboard for 3–6 hours and 6–8 hours respectively. More than Eight hours keyboard usage times were reported by 14 (18.2%) subjects. There was no significant relationship between the dominant

and non-dominant hand grip strength with the key board usage hours (P = 0.091, P = 0.064) respectively (see Table 2).

Table 2 The Mean Values for Hand Grip Strengths of the Dominant and Non-dominant Hands According to Keyboard Usage Hours

Hours of keyboard usage	Dominant hand		Non-dominant hand	
	Mean	(SD)	Mean	(SD)
Less than 3 hours	29.16	10.00	26.7	10.12
3 to 6 hours	24.7	7.27	21.67	7.45
6 to 8 hours	25.6	7.92	22.4	7.4
More than 8 hours	28.33	8.60	24.22	10.43

Source: Devised by authors

For the lifestyle 18 (23.4%) subjects had an active lifestyle and did exercises such as jogging, swimming, football, or weight lifting; 59 (76.6%) subjects had a sedentary lifestyle. The mean value of the dominant grip strength for the active and sedentary subjects was 22.8kg (±6.6) and 21.8kg (±3.4) respectively, while the mean value for the non-dominant hand grip strength for the active subjects was 19.2kg (±5.5) and for the sedentary was 19.1kg (±3.8). There was no significant difference (P = 0.96) in non-dominant hand grip and lifestyle, also (P = 0.59) between dominant grip strength and lifestyle.

Regarding hand exercises, there were 5 (6.5%) subjects who practiced, while 72 subjects (93.5%) did not. The hand grip strength and hand strengthening exercises showed no significant difference (P = 0.83 and P = 0.71) in the dominant and non-dominant hands respectively.

Regarding hand dominance, 63 (81.8%) subjects were right handed and 9 (11.7%) subjects were left handed. The mean of the dominant hand grip strength among right handed subjects was 22.4kg (±4.9), while among left handed subjects it was 19.6kg (3.6). On the other hand, the mean of the non-dominant hand grip strength of the right handed subjects was 18.91kg (±4.18), while among the left handed it was 19.1kg (±5.5). There was no significant correlation between hand grip strength dominance and handedness (see Table 3).

Table 3 Difference Between Right or Left Handedness and the Hand Grip Strength in the Dominant and Non-dominant Hand

	Dominant hand grip strength	Right or Left handedness	Non-dominant hand grip strength	Right or Left handedness
T-test	1.625		0.761	
(Sig.)	P = 0.109 No significance		P = 0.449 No significance	

Source: Devised by authors

Concerning skilful hand hobbies, the majority of the subjects (47, 61.1%) were not doing any skilful hand hobbies, and only 30 (38.9%) subjects were doing hobbies. The mean of the dominant hand grip strength for the subjects who practice skilful hand hobbies was 22.5kg (5.2), while the mean of the subjects who did not was 21.66kg (±8.33). The mean of the non-dominant hand grip strength was 19.4kg (4.2) for the subjects who practiced skilful hand hobbies, and 17.9kg (3.9), for the subjects who did not. There was no significant difference in either dominant or non-dominant hand grip strength ($P = 0.209$ & $P = 0.122$) respectively between the two groups.

DISCUSSION

Hand grip strength is a measure of strength of the hand and the forearm muscles; it is measured in kilograms using a hand grip dynamometer (Pieterse et al., 2002). It is also an important component of hand rehabilitation because it is a measure of the effectiveness of therapy (Fraser and Benten, 1983). It can evaluate the ergonomics especially for using hand tools (Dhara et al., 2009). In addition, a hand grip dynamometer is a reliable and valid evaluation of hand strength that is essential in determining the effectiveness of various surgical or treatment procedures. A base line grip strength value for the normal population is needed; however, data derived from certain populations cannot be applied to a comparable population (Kamarul et al., 2006).

Many daily functions and sports require high activity levels of the flexor musculature of the forearms and hands. They are the muscles that are involved in gripping strength. In sports such as volley ball, basketball, wrestling, tennis and baseball, to daily activities such as carrying laundry, turning a doorknob and vacuuming, some degree of grip strength is necessary to be successful. It is often disregarded; the strength of one's grip plays a key role in injury prevention and overall strength development (Tietjen-Smith et al., 2006).

A total of 77 female students from Ahlia University were included in this study. They were asked to complete a demographic data sheet, and then measurements of their weight, height, dominant and non-dominant hand grip strength, TAL and MUAC were taken.

The current study showed mean hand grip strength of 22.22kg (4.7) for the dominant hand and 18.98kg (4.3) for the non-dominant hand. In comparison to other population reference values in age matched groups, it was found that Bahraini females have much lower hand grip strength; the comparison showed for the dominant hand 30kg (7) in the Australian population (Massy-Westropp et al., 2011), 25.9kg in the Malaysian population (Kamarul et al., 2006), 25.1kg in the Nigerian population (Adedoyin et al., 2009), and 27.2kg in the Brazilian population (Schlussel et al., 2008). This raised a concern about this lower hand grip strength that reflects the strength of the whole body. Research should be directed to this point.

Furthermore, there is a significant difference ($P = 0.0001$) between the means of dominant and non-dominant hand grip strength, with the dominant hand being

stronger than the non-dominant by 14.5%. Handedness is an important factor for the forceful flexion of all finger joints and afterwards generates the hand grip strength; therefore, the dominant hand will develop stronger muscles than the non-dominant, seeing that it is used more in different activities. This was supported by Koley and Singh (2010), who stated that the dominant hand is approximately 10% stronger than the non-dominant hand.

Koley and Singh (2010) and Bagi et al. (2011) support the current study comparisons between right and left handedness of dominant and non-dominant hands, and no significant differences were found. Therefore, the right and left handedness does not affect the hand grip strength ($P = 0.109$, 0.449) in the dominant and non-dominant hand respectively. Handedness is the factor that affects the strength of the grip, not whether it's right or left.

The main findings related to the BMI showed a significant relationship between BMI and the grip strength of the dominant hand ($P = 0.017$), while non-significant in the non-dominant hand ($P = 0.103$). There was a proportional relationship until overweight subjects were included, which represented the peak, but when it reached the obesity level it started to decline. BMI is an indicator of muscle mass and fat mass; as the BMI increases the fat and muscle mass increases. The current study showed the peak of hand grip strength was in participants with obesity class 2; this is in agreement with the same findings by Jürimäe and Jürimäe (1998), who reported higher hand grip strength values in obese women compared to the non-obese. The current result is in contradiction with Hulens et al. (2001), who found lower hand grip in obese people and explained that this is due to the low physical activity level and sedentary life style. Also Rolland et al. (2004) added that obesity changes the muscular architectural components such as fat infiltration. The current study showed non-significant differences in both dominant and non-dominant grip strength in either an active or sedentary lifestyle.

TAL showed a highly significant correlation ($P = 0.003$ & $P = 0.049$) with the hand grip strength of the dominant and non-dominant hands respectively. Koley and Singh (2010) disagreed with this result, and concluded that there was no relationship ($P = 0.218$) between the total arm length and hand grip strength. Due to the limited number of references, we could not find a study that supported or explained our results.

Regarding the MUAC, hand grip strength showed a significant correlation ($P = 0.02$) for the dominant hand, while it was non-significant ($P = 0.09$) for the non-dominant hand. In contrast, Watters et al. (1985) stated that the MUAC did not correlate with hand grip strength, and that might be because muscle efficiency may be more important than muscle mass. However, this may be not true as Koley and Singh (2010) concluded a different opinion, that males' MUAC had greater values for that anthropometric measure and greater hand grip strength values than their female counterparts. So it is somewhat hand grip relays on the muscle mass that represented MUAC.

According to Rolland et al. (2004), physical activity improves muscle strength and muscle mass, which, in turn, improves hand grip strength. Simons and Travell (1983)

had consistently used a comprehensive hand strengthening approach to address grip strength training and rehabilitation. They justified that powerful flexion of distal phalanges requires strong activity of the finger extensors as well, and both are needed to produce a forceful hand grip. In other words, strengthening the flexors and extensors of the hand leads to more powerful grip strength.

In the current study, lifestyle and performance hand exercises both showed a non-significant relationship with the hand grip strength. The explanation of the current results is the number discrepancy between subjects in both lifestyle and hand exercises. Therefore, further investigation on this point is needed, with a larger number of active subjects.

However, the effect of keyboard usage hours and performing skilful hand hobbies on the grip strength was not significant. We could not find evidence in the literature that supports or disagrees with our results, as they focussed on other factors rather than these. These results could be due to the fact that keyboard usage, as well as the types of hobbies, does not require forceful contraction of the hands' muscles. Rather, they were just simple movements.

CONCLUSIONS

We can conclude that the factors that showed a significant relationship with hand grip strength should be taken into consideration, especially with patients undergoing hand rehabilitation. These subjects need improvement in hand grip strength, as well as any individual who is looking for a more powerful hand grip. We can predict the average baseline of the hand grip strength of young Bahraini adults.

Key Messages

1) Key findings
   - Hand grip strength showed a significant relationship with many factors, which are BMI, gender, lifestyle, hand strengthening exercises, total arm length and MUAC;
   - Hand grip strength shows a non-significant relationship with other factors, which are keyboard usage hours, dominance and handedness, and skillful hand hobbies.
2) What the study has added

   This study gave a reference regarding the average hand grip strength of Bahraini female youths to be used in hand rehabilitation programmes, as well as clarification of other factors that can affect the hand grip strength.

Conflict of Interest

All the authors declare that there was no potential conflict of interest.

REFERENCES

Adedoyin, R.A., Ogundapo, F.A., Mbada, C.E., Adekanla, B.A., Johnson, O.E., Onigbinde, T.A. and Emechete, A.A. (2009), Reference Values for Handgrip Strength among Healthy Adults in Nigeria. *Hong Kong Physiotherapy Journal*, Vol. 27, No. 1, pp. 21–29.

Angst, F., Drerup, S., Werle, S., Herren, D., Simmen, B. and Goldhahn, J. (2010), Prediction of grip and key pinch strength in 978 healthy subjects. *BMC Musculoskeletal Disorders Electronic Journal*, Vol. 11, No. 1, p. 94 doi:10.1186/1471-2474-11-94.

Artero, E., España-Romero, V., Ortega, F., Jiménez-Pavón, D., Ruiz, J., Vicente-Rodriguez, G. and Bueno, M. (2009), Health-related fitness in adolescents: underweight, and not only overweight, as an influencing factor, The AVENA study. *Scandinavian Journal of Medical Sciences Sports*, Vol. 595, pp. 1–10.

Bagi, J.C., Kundachi, P.S. and Goudar, S.S. (2011), Influence of motor tasks on handedness. Al Ameen *Journal of Medical Sciences*, Vol. 4, No. 10, pp. 87–91.

Center for Disease Control (2007), National health and nutrition examination survey: *Anthropometry Procedures Manual*, pp. 3–15.

Costa, T., Lima, T., Gontijo, P., Carvalho, H., Cardoso, F., Faria, O. and Cavalcanti Neto, F. (2010), Correlation of respiratory muscle strength with anthropometric variables of normal-weight and obese women. *Revista da Associação Médica Brasileira*, Vol. 56, No. 4, pp. 403–08.

Dhara, P., De, S., Pal, A., Sengupta, P. and Roy, S. (2009), Assessment of Hand Grip Strength of Orthopedically Challenged Persons Affected with Upper Extremity. *Journal of Life Sciences*, Vol. 1, No. 2, pp. 121–27.

Fraser, C. and Benten, J. (1983), A study of adult hand strength. *British Journal of Occupational Therapy*, Vol. 46, No. 10, pp. 296–99.

Haboubi, N., Hudson, P. and Pathy, M. (1990), Measurement of height in the elderly. *Journal of the American Geriatric Society*, Vol. 38, No. 9, pp. 1008–1010.

Hulens, M., Vansant, G., Lysens, R., Claessens, A., Muls, E. and Brumagne, S. (2001), Study of differences in peripheral muscle strength of lean versus obese women: an allometric approach, *International Journal of Obesity*, Vol. 25, No. 5, pp. 676–81.

Jürimäe, T. and Jürimäe, J. (1998), Anthropometric and health-related fitness characteristics in middle-aged obese women. *Collegium Antropologicum*, Vol. 22, No. 1, pp. 97–106.

Kamarul, T., Ahmad, T. and Loh, W. (2006), Hand grip strength in the adult Malaysian population. *Journal of Orthopaedic Surgery*, Vol. 14, No. 2, pp. 172–77.

Koley, S. and Singh, A. (2010), Effect of Hand Dominance in Grip Strength in Collegiate Population of Amritsar Punjab, India. *Anthropologist*, Vol. 12, No. 1, pp. 13–16.

Koley, S. and Singh, A.P. (2009), An association of dominant handgrip strength with some anthropometric variables in Indian collegiate population. *Anthropologischer Anzeiger*, Vol. 67, No. 1, pp. 21–28.

Koley, S., Yadav, M. and Sandhu, J. (2009), Estimation of hand grip strength and its association with some anthropometric traits and cricketers of Amritsar, Punjab, India. *The Internet Journal of Biological Anthropology*, Vol. 3, No. 1, pp. 7–12.

Massy-Westropp, N., Gill, T., Taylor, A., Bohannon, R. and Hill, C. (2011), Hand Grip Strength: age and gender stratified normative data in a population-based study. *BMC Res Notes*, Vol. 4, No. 1, p. 127.

Palastanga, N., Field, D. and Soames, R. (2006), *Anatomy and human movement, structure and function*. Elsevier, 5th edn, p. 188.

Pieterse, S., Manandhar, M. and Ismail, S. (2002), The association between nutritional status and handgrip strength in older Rwandan refugees. *European Journal of Clinical Nutrition*, Vol. 56, No. 10, pp. 933–39.

Richards, L. and Palmiter-Thomas, P. (1996), Grip strength measurement: A critical review of tools, methods, and clinical utility. *Critical Reviews in Physical and Rehabilitation Medicine*, Vol. 8, Nos 1–2, pp. 87–109.

Rolland, Y., Lauwers-Cances, V., Pahor, M., Fillaux, J., Grandjean, H. and Vellas, B. (2004), Muscle strength in obese elderly women: effect of recreational physical activity in a cross-sectional study. *The American Journal of Clinical Nutrition*, Vol. 79, No. 4, pp. 552–57.

Ruiz, J., España-Romero, V., Ortega, F., Sjöström, M., Castillo, M. and Gutierrez, A. (2006), Hand span influences optimal grip span in male and female teenagers. *The Journal of Hand Surgery*, Vol. 31, No. 8, pp. 1367–72.

Schlussel, M., dos Anjos, L., de Vasconcellos, M. and Kac, G. (2008), Reference values of handgrip dynamometry of healthy adults: A population-based study. *Clinical Nutrition*, Vol. 27, No. 4, pp. 601–7.

Simons, D.G. and Travell, J.G. (1983), *Myofascial Pain and Dysfunction - The Trigger Point Manual, Volume 1, Upper Extremities*. Williams & Wilkins Company, 2nd edition, Chapter 35, p. 501.

Tietjen-Smith, T., Smith, S., Martin, M., Henry, R., Weeks, S. and Bryant, A. (2006), Grip Strength in Relation to Overall Strength and Functional Capacity in Very Old and Oldest Old Females. *Physical & Occupational Therapy in Geriatrics*, Vol. 24, No. 4, pp. 63–78.

Vas, M., Thangam, S., Prabhu, A. and Shetty, P. (1996), Maximal voluntary contraction as a functional indicator of adult chronic under nutrition. *British Journal of Nutrition*, Vol. 76, No. 1, pp. 9–15.

Watters, D., Haffeji, A., Angorn, I. and Duffy, K. (1985), Nutritional assessment by hand grip dynamometry. *South African Med J*, Vol. 68, No. 12, pp. 585–87.

Weinick, J. (1990), *The importance of grip strength, Functional Anatomy in Sports*. Mosby-Year Book Inc., St. Louis, p. 81.

BIOGRAPHY

Dr Dalia M Kamel is currently an Associate Professor of Physiotherapy at Ahlia University, Kingdom of Bahrain. She has published and reviewed many papers in refereed journals such as *J Back* and *Musculoskeletal Rehabilitation*.

Fatima Ebrahim Mirza has been a physiotherapist at the physioRelief physiotherapy centre since February 2012. She has attended several postgraduate courses in manual therapy. She gained a BSc in physiotherapy from Ahlia University, Kingdom of Bahrain in 2011.

Fatima Hilal Al-Zaki has been a Supervisor Physiotherapist at the Physiocare physiotherapy centre in Bahrain since April 2014. She gained a BSc in Physiotherapy from Ahlia University, Kingdom of Bahrain in 2011.

Dr Jenan Jassim Al Sehali is the founder of the Jenan Physiotherapy Clinic (April 2014). Dr Al-Sehali gained a BSc from Ahlia University, Kingdom of Bahrain in 2011 and a DPT from the University of Southern California in 2015. She also has several manual therapy certifications and post graduate qualifications.

Zahra Abdulameer Abdulla is a Physiotherapist at Physiocare Physiotherapy centre She gained a BSc from Ahlia University, Kingdom of Bahrain in 2011.