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Physical Exercise Activity to Increase The Handgrip Strength in Elderly Population During Covid-19: A Prospective Study

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[1]Substantial contributions to the conception or design of the work, Principal researcher
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ABSTRACT

Objective: To determine palmar grip force (PGF) in the elderly population and its correlation with different parameters used in the usual practice of evaluation of nutritional status in an elderly population.

Methodology: It was an observational, cross-sectional study. 300 elderly people over 65 years old, who were doing gym exercises at UFC gym and Structure gym, Lahore from December 2019 to July 2020. HS was obtained using the digital dynamometer model EH101, using the average of three measurements. The cutoff point considered for low muscle strength was HS < 27 kg for men and < 16 kg for women. The standard has been taken according to the 2019 consensus of the European Working Group on Sarcopenia in Older People (EWGSOP2, version 2019). For the statistical analysis, the Statistical Package for Social Science 24.0 program was used and chi square test was applied, considering it significant when p <0.05.

Results: The sample consisted of elderly people with a mean age of 71.71 ± 5.97 years, of which 28% were aged between 65 and 75 years and 51.66% were male. In the analysis of the HS, we found 57.9% of the elderly with loss of muscle strength due to non-exercise during COVID-19. The muscle circumference of the arm and tricipital skin fold indicators found the highest percentages of malnutrition, 44.1%, and 57.8%, respectively. HS showed a positive association between age and handgrip test levels.

Conclusion: There was a high frequency of elderly people with impaired strength, but HS correlated only with APMT, not showing a direct relationship with other anthropometric parameters used in the routine practice of assessment with the elderly. Therefore, HS, or at least the evaluation of APMT, becomes indispensable for the evaluation and physical exercise training of elderly persons during COVID-19 pandemic.

Keywords: Handgrip strength, physical exercise, nutritional assessment, elderly, gym exercise.

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Introduction

Physical exercise activity is necessary for elderly persons to keep anatomical and physiological functions in old age. Due to COVID-19 pandemic, it has become difficult for the elderly to move out and carry out physical exercises at indoor gyms and outdoor parks. The importance of handgrip strength in the elderly is very important to be maintained as it is considered to be a benchmark for a reduction in strength and physiological functions. It further increases the elder's vulnerable to have dependence. Along with the decrease in the handgrip, the grip speed slowdowns, weight loss begin to occur, short breath exhaustion occurs after a small physical activity. The simplest method adopted during the COVID-19 to find out the physical ability of the elderly is the handgrip test.

The palmar grip force (PGF) is one of the criteria used by the American Society for Parenteral and Enteral Nutrition (ASPEN) for the diagnosis of malnutrition,

besides being a determinant of clinical results associated to it. Low grip strength is a powerful predictor of unfavorable outcomes for elderly patients, such as longer hospital stay, increased functional limitations, health-related quality of life, and death.[1]

Grasping strength correlates moderately with strength in other compartments of the body, so it serves as a reliable substitute for more complicated arm and leg strength measures. Because of its ease of use, grip strength is recommended for routine use in hospital practice, specialized clinical settings, and community health services for determining the health condition of elderly persons.[2]

Mass and muscle strength vary throughout life, usually increasing with the growth in youth and young adulthood, being maintained in middle age and decreasing with aging. In young adulthood, until mid-40 years of age, we reach peak levels, which are higher in men than in women.[3] On average, older individuals experience annual losses of mass and muscle strength of 1% and 3% respectively.[4] However, the variation in the rates of decline in mass and muscle strength in the population points to an influence of modifiable behavioral factors, such as diet and lifestyle and on the etiology of sarcopenia, suggesting that these factors can be effective in both prevention and treatment.[5]

The evaluation of PGF is an import0nt parameter for determining the effectiveness of various therapeutic strategies, as well as setting treatment goals, and evaluating the patient's ability to return to functional activities.[6]

The main objective of the study was to investigate palmar grip force (PGF) in the elderly and its correlation with different parameters used in the usual practice of evaluation of nutritional status in the elderly population.

Methodology

This is observational and cross-sectional approach research conducted with 300 elderly persons who were doing gym exercises at UFC gym and Structure gym, Lahore To calculate the sample size the simple random sampling method was used, considering the number of elderly persons between December 2019 to July 2020 and the variance obtained through available data on the body mass index (BMI) of these elderly, the whose estimated variance was 5.44 kg/m2 and an estimation error of the average of 1.49 kg/m2, obtaining a minimum sample of 92 elderly with a 95% confidence level.

Inclusion Criteria: Individuals with age ≥ 65 years and who have joined gym for exercise for one hour in a day and voluntarily consented to performed the palmer grip force test.

Exclusion Criteria: Persons were excluded from the survey individual's bedridden, amputees, with the presence of edema, ascites or anasarca, pacemaker carriers, with dementia or other cognitive disability that would compromise the understanding about the procedures performed.

The data were collected by two nutritionists from gyms having experience in the evaluation of the elderly, through the completion of a semi-structured questionnaire containing sociodemographic data, anthropometric measurements and the mini nutritional evaluation (MNE). Besides these measures, the strength of the palmar grip force (PGF) and thickness of the adductor thumb muscle (ATM) were measured.

The PGF was measured using the digital dynamometer model EH101 with a capacity of 90kg, with the patient seated, with the feet supported on the floor, elbow flexed at 90º, with the forearm next to the body and the equipment adjusted to the size of the patient's hand, being applied the maximum palmar grip force for about three seconds, in triplicate, with intervals of 30 seconds between one measurement and another, being considered the average of the three measurements. It was used as cut point for low PGF classification the values below 27 kg for men and 16 kg for women, respectively.[7] The measurements were obtained in the dominant arm.

ATM was obtained through a scientific Adipometro, Cescorf® mark, with 1mm precision, and performed with the elderly seated with the arm inclined and the hand resting on the knee, whose measurement occurred with the forceps of the adductor muscle at the apex of an imaginary triangle formed by the extension of the thumb and forefinger of the dominant hand, in triplicate, being considered the average of the three measurements. The elderly with values below 13.3 mm were considered malnourished, according to Bragagnolo et al.[8]

As a measure of subjective nutritional assessment, MNA (Mini Nutritional Assessment) was used and the nutritional status was defined through the sum of the scores, considering adequate when ≥ 23 points, risk of

malnutrition with scores between 16 and 22.5 and malnutrition with < 16 points.[9]

The anthropometric measurements collected were weight, height, arm circumference (AC), triceps skinfold (TSF), arm muscle circumference (AMC) and calf circumference (CC).

The Body Mass Index (BMI) was determined from weight and height measurements, dividing the weight by the square of height, whose cut-points used were those proposed by the Pan American Health Organization (PAHO)[10], considering eutrophy, BMI between 22 and 27Kg/m2, malnourished, BMI below 22Kg/m2; overweight, BMI between 27 and 29Kg/m2; and obese those with values above 28Kg/m2.

To evaluate the percentage of adequacy of AC, TSF and AMC. We used the reference values (50th percentile) of the National Health and Nutrition Examination Survey III (NHANES III), demonstrated in table of percentiles by Frisancho[11] and the nutritional status classified according to Blackburn and Thornton.[12]

For measurement of calf circumference (CC), an inelastic tape was used in the region of the greater circumference with the patients seated, with the feet fully supported on the ground, with the knee flexed at an angle of 90º. AC can be considered adequate when it is equal to or greater than 30cm for both sexes.[13]

The data were tabulated in Microsoft Excel Software and analyzed through SPSS version 24.0. In the statistical analysis, we used Pearson's Correlation, whose coefficient values were interpreted through the following criteria: weak correlation ($r<0.30$); regular correlation (r between 0.30 and 0.60); strong correlation (r between 0.60 and 0.90); and very strong correlation ($r>0.90$). It was considered a statistically significant correlation with $p<0.05$ value.

The research met all the requirements of the Gulab Devi Educational Complex ethics committee. The project was approved by the Research Ethics Committee of the Department of Physiotherapy, Gulab Devi Educational Complex, and Lahore, Pakistan. All the individuals were informed about the study procedures and signed the Free and Informed Consent Term.

Results

Mostly older people belong to the age group between 75-80. The average age was 71.71 ±5.97 years. Figure 1. Out of 300 participants, 155 (51.66%) were male and 145 (48.33%) female (Figure 2). Most of the participants (81.8%) did not have any work activity. The results of this evaluation demonstrate that around 30% of the individuals studied presented some degree of malnutrition when using anthropometric parameters of routine use in clinical practice in caring for the elderly, such as BMI and calf circumference. This percentage increases as other anthropometric parameters related to body composition were performed, such as TSF, in which 129 (43%) elderly individuals assessed some degree of depletion of adipose tissue and AMC, in which 143 (47.33%) showed some degree of lean mass depletion. This shows the classification of the nutritional status of the elderly evaluated, according to the usual anthropometric parameters for evaluating the nutritional status. (Table I)

Out of 300 participants, 70(23%) were in age group of 65-70, 146(49%) were in the age group of 75-80, 84(28%) were in age group of 80-85.

Out of 300 participants, 155 were male and 145 were female.

The use of MNA found that 75 (73.5%) of the elderly evaluated were at risk or malnutrition already at the beginning of the study. These findings were confirmed when performing APMT, in which 75 (73.5%) of the individuals already had malnutrition, and when performing the PGF, it was detected that 59 (57.8%) elderly people presented loss of muscle strength, indicating impaired functionality and a possible increased risk of negative outcomes during exercise. it describes the classification of nutritional status using subjective assessment indicators and anthropometric assessment parameters not usually used in clinical practice such as PGF and AMC. (Table II)

The analyses show that there was no correlation between PGF and the usual anthropometric parameters of nutritional assessment of the elderly. Only when comparing PGF to APMT, a moderately positive correlation was observed ($r=0.541$; $p<0.001$).it shows the analysis of the correlation between PGF and other anthropometric and subjective parameters used in the nutritional assessment of the elderly. (Table III)

After applying chi square test and check the association of gender and age groups with hand grip categories which explains exercise effects among them there is significant results were found between those attributes.

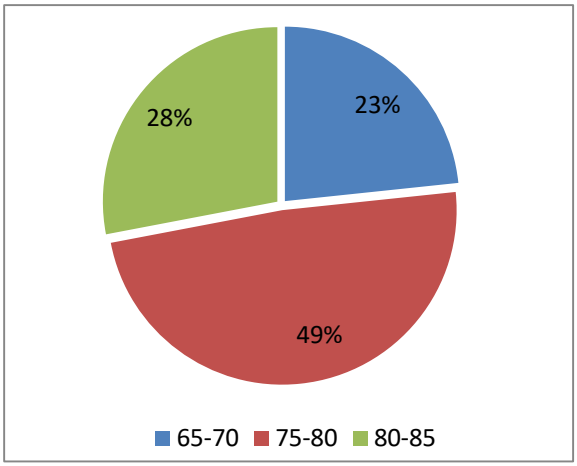

Figure1. Age distribution.

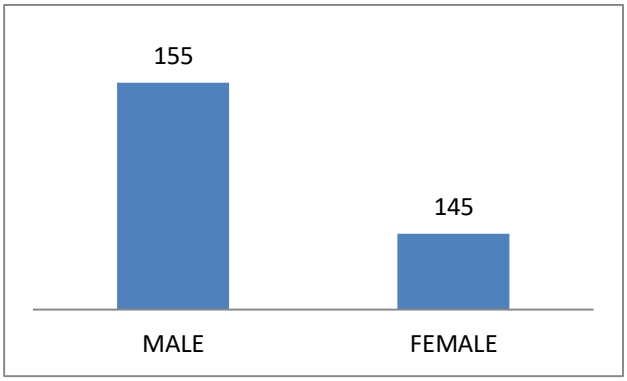

Figure 2. Gender distribution.

Table I. Nutritional status according to different anthropometric parameters for evaluating the nutritional status in the elderly population under study (n=300)

Classification Parameter	**N (%)**
Body mass index (BMI)	
Low weight	131 (43.66)
Adequate	29 (9.66)
Pre-obesity / Obesity	140 (46.66)
Calf circumference (CC)	
Depletion	160 (53.33)
Adequate	140 (46.66)
Arm circumference (AC)	
Malnutrition	102 (34)
Proper	82 (27)
Overweight / Obesity	116 (38.66)
Triceps skin fold (TSF)	
Malnutrition	129 (43)
Proper	111 (37)
Overweight / Obesity	60 (20)
Arm muscle circumference (AMC)	
Malnutrition	143 (47.66)
Proper	157 (52.33)

Table II: Nutritional status according to MNA, PGF and APMT in elderly indexed population (n = 300)

Classification Parameter	**N (%)**
Mini nutritional assessment (MNA)	
Malnutrition	133 (44.33)
Malnutrition risk	99 (33)
Adequate	68 (22.66)
Handgrip strength (PGF)	
Loss of muscle strength	159 (53)
Preserved muscle strength	141 (47)
Adductor pollicis muscle thickness (APMT)	
Malnutrition	157 (52)
Proper	143 (47.66)

Table III: Correlation between handgrip strength and anthropometric and subjective parameters of nutritional assessment in elderly indexed population (n = 102)

Parameter	**Correlation coefficient**	**p-value**
Weight loss (%)	-0.001	0.994
BMI (Kg / m2)	-0.128	0.366
AC (%)	-0.018	0.893
CC (cm)	0.157	0.268
MCA (%)	0.226	0.110
TSF	0.264	0.059
TATM (cm)	0.541	<0.001
MNA (Score)	0.238	0.090

BMI: body mass index; AC: arm circumference; CC: calf circumference; MCA: muscle circumference of the arm; TSF: tricipital skin fold; TATM: the thickness of the adult thumb muscle; MNA: mini nutritional assessment.

Table IV: Association of handgrip with age and gender

Gender	Week	Normal	Strong	Total	p-values
MALE	30	50	75	155	0.021
FEMALE	45	50	50	145	
Age group					
65-70	19	21	30	70	.001
75-80	40	80	26	146	
80-85	20	44	20	84	
Total				300	

Discussion

Regarding the characteristics of the sample, the present study evidenced the predominance of elderly women, corroborating the profile of the Brazilian demographic pattern, whose absolute number of elderly women is higher than men over 60 years.[14,15]

The fact that most of the sample presents unfavorable socioeconomic conditions. The mean age was similar to other findings that studied grip strength in elderly individuals.[16,17,18] It is already a consensus in the scientific literature that increased age is directly related to the reduction of PGF associated with aging.[19] It is worth noting that this reduction was identified in more than half of the population in this study.

PGF has been used as a strong predictor of functionality and when decreased it is related to a higher risk for future dependency and worse health condition (5,6). In this perspective, the results found in this research become worrisome, since almost 60% of the evaluated elderly presented loss of muscle strength already at the beginning of the study, which when added to their already compromised health situation worsens, even more, the clinical prognosis.

These findings are reinforced when analyzing the results found by Tavares et al. [20], when evaluating 123 elderly women in southern Brazil, observed that the occurrence of falls (at least one occurrence per year) occurred more frequently in individuals with lower PGF. This data suggests a worse functionality of these individuals with a greater tendency to body imbalance and the occurrence of new falls with, consequently, a greater possibility of needing hospital admission.

Regarding the nutritional diagnosis when evaluated the anthropometric measures used in the most usual way, it was observed that BMI, although it is not the most accurate method to evaluate the elderly, still presented results of malnutrition above that reported in other studies with a profile of similar patients.[17,21]

When using anthropometric composition measures such as MCA and TSF it can be observed that the diagnosis of malnutrition, muscle loss, and fat tissue was increasing. On the other hand, these findings did not present a significant correlation with PGF. This result can be explained by the possible nondirect association between these parameters since although the relationship between greater lean mass may be associated with greater physical strength, this is still related to cognitive strength and comorbidities present in the individual. The presence of osteoporosis and pain, besides malnutrition and decrease of skeletal muscle, may influence the grip strength and general muscle strength of the elderly.[22]

In a population-based study conducted in southern Brazil with approximately 1400 elderly, it was observed that those with inadequate anthropometric parameters, such as low body mass index, already reflected in the loss of functional capacity and were associated with early stages of sarcopenia.[23]

On the other hand, regular exercise can increase or prevent the loss of manual strength. Tolentino et al. studying physically active elderly women, observed that although they presented a statistically significant reduction in body mass and BMI, in women over 68 years of age, PGF was considered adequate in 77%, demonstrating the benefits of physical activity in preserving muscle strength despite age.[24]

When using MNA as a parameter for subjective assessment of nutritional status whose assessment considers, in addition to anthropometric parameters, the characteristic changes of age, such as changes in mobility, autonomy in nutrition, self-perception of health, among others; it was observed that almost 75% of the sample presented risk or diagnosis of malnutrition. Despite the high frequency of unfavorable nutritional diagnosis when evaluated this parameter, the correlation between MNA and PGF was weak and not significant in the sample studied.

On the other hand, a study conducted with 42 elderly people attending the outpatient clinic of a university hospital in São Paulo found an average positive correlation of 40% only between MNA and PGF, among other parameters of evaluation of nutritional status such as BMI, arm circumference and calf.[25]

Labott et al. carried out a meta-analytical review on the effects of exercise training on handgrip strength in older adults. He found out that physical exercise training greater effect on handgrip strength in the elderly population.[26]

Bilajac et al. Researched the influence of physical activity on the handgrip strength of the elderly population. He found out that physical exercise activity influences on handgrip strength of elder persons.[27]

Alqahtani et al. Carried out a cross-sectional study on reference values and associated factors of handgrip strength in the elderly population. He found out that physical exercise plays a greater role to improve the handgrip strength in the elderly population of the Kingdom of Saudi Arebia.[28]

It can be inferred that the collection of standardized anthropometric measurements performed by experts constitutes a strong point in the present study, due to the several difficulties encountered in the nutritional evaluation of the elderly population, due to their clinical conditions.

In contrast, there are still few collection protocols and standardizations for the evaluation of PGF, which may generate difficulties in comparing results regarding the use of PGF.[22]

The reduced strength of palmar grip (PGF) is directly related to the occurrence of several chronic morbidities, which reinforces the need for its assessment, as an essential marker in the clinical evaluation of the elderly[29]; considering that it is a validated parameter, which can be used to compare the effectiveness of several procedures, define goals of several therapies and also evaluate the functionality of patients. Besides being of simple execution, low cost, and fast application.[30]

Conclusion

The clinical importance of the findings of this study is highlighted, in which more than half of the elderly already have a deficit of functionality evidenced by the assessment of PGF and may be directly associated with the clinical prognosis of these individuals. In addition, the diagnosis of malnutrition and deficit of muscle mass and fat tissue was quite frequent.

In addition, the failure to observe the correlation of PGF with other parameters used more routinely in clinical practice such as BMI, CC, AC, TSF, MCA, and MNA, makes clear that these indicators are not able to signal early changes in functionality, which may lead to the planning of therapeutic strategies not assertive, in addition to the possibility of losing time for an intervention.

In the absence of the dynamometer for PGF measurement, the TATM evaluation can be an option to signal changes in the individual's functionality.

These findings demonstrate the need for the most complete nutritional assessment in the elderly, using all available resources in each service, since these indicators complement each other, providing the professional with a broader and individualized view of the nutritional diagnosis of each patient, favoring the most appropriate therapeutic planning.

References

1. Ibrahim K, May C, Patel HP, Baxter M, Sayer AA, Roberts H. A feasibility study of implementing grip strength measurement into routine hospital practice (GRImP): study protocol. Pilot and feasibility studies. 2016 Dec;2(1):1-0.
2. Beaudart C, McCloskey E, Bruyère O, Cesari M, Rolland Y, Rizzoli R, de Carvalho IA, Thiyagarajan JA, Bautmans I, Bertière MC, Brandi ML. Sarcopenia in daily practice: assessment and management. BMC geriatrics. 2016 Dec;16(1):1-0.
3. Keller K, Engelhardt M. Strength and muscle mass loss with aging process. Age and strength loss. Muscles, ligaments and tendons journal. 2013 Oct;3(4):346.
4. Pourhassan M, Rommersbach N, Lueg G, Klimek C, Schnatmann M, Liermann D, Janssen G, Wirth R. The impact of malnutrition on acute muscle wasting in frail older hospitalized patients. Nutrients. 2020 May;12(5):1387.
5. Robinson SM, Reginster JY, Rizzoli R, Shaw SC, Kanis JA, Bautmans I, Bischoff-Ferrari H, Bruyère O, Cesari M, Dawson-Hughes B, Fielding RA. Does nutrition play a role in the prevention and management of sarcopenia?. Clinical Nutrition. 2018 Aug 1;37(4):1121-32.
6. Figueiredo IM, Sampaio RF, Mancini MC, Silva FC, Souza MA. Test of grip strength using the Jamar dynamometer. Acta Fisiatrica. 2007 Jun 9; 14 (2): 104-10.
7. Cruz-Jentoft AJ, Bahat G, Bauer J, Boirie Y, Bruyère O, Cederholm T, Cooper C, Landi F, Rolland Y, Sayer AA, Schneider SM. Sarcopenia: revised European consensus on definition and diagnosis. Age and ageing. 2019 Jan 1;48(1):16-31.
8. Bragagnolo R, Caporossi FS, Dock-Nascimento DB. Adductor pollicis muscle thickness: a fast and reliable method for nutritional assessment in surgical patients. Revista do Colégio Brasileiro de Cirurgiões. 2009 Oct;36(5):371-6.
9. Guigoz Y, Lauque S, Vellas BJ. Identifying the elderly at risk for malnutrition. The Mini Nutritional Assessment. Clinics in geriatric medicine. 2002 Nov 1;18(4):737-57.
10. Pan American Health Organization (PAHO). Health, Well-being and Aging (SABE) - The SABE Project in the city of São Paulo: an initial approach. Brasília: PAHO, 2003.
11. Frisancho, A. R. Anthropometric Standards: an Interactive Nutritional Reference of Body Size and Body Composition for Children and Adults. University Michigan, 2008.
12. Blackburn GL, Thornton PA. Nutritional assessment of the hospitalized patient. The Medical clinics of North America. 1979 Sep 1;63(5):11103-15.
13. World Health Organization (WHO). Physical status: the use and interpretation of anthropometry [text on the Internet]; 1995. Geneva: WHO; 1995 [Technical Report Series No. 854]. [cited 2015 Jun 24] Available at: http://www.who.int/childgrowth/publications/ physical_status / en /
14. de Oliveira EN, dos Santos KT, dos Reis LA. Handgrip strength as an indicator of functionality in the elderly. Revista Pesquisa em Fisioterapia. 2017 Aug 29; 7 (3): 384-92.
15. Confortin SC, Ono LM, Meneghini V, Pastorio A, Barbosa AR, d'ORSI E. Factors associated with handgrip strength in older adults residents in Florianópolis, Brazil: EpiFloripa Aging Study. Revista de Nutrição. 2018 Aug;31(4):385-95.
16. Riviati N, Setiati S, Laksmi PW, Abdullah M. Factors related with handgrip strength in elderly patients. Acta Med Indones. 2017 Jul 1;49(3):215-9.
17. Araújo RG, de Moura RB, Cabral CS, de Paiva GT, Cavalcanti IC, dos Santos Olinto EO, Barbosa JM, de Araújo ÂA. Correlação da força de preensão palmar e parâmetros nutricionais em idosos hospitalizados. Brazilian Journal of Health Review. 2020 Nov 6;3(6):15838-51.
18. Bohannon RW. Grip Strength: An Indispensable

Biomarker For Older Adults. Clin Interv Aging. 2019 Oct 1;14:1681-1691. doi: 10.2147/CIA.S194543. PMID: 31631989; PMCID: PMC6778477.

19. Contreras-Bolívar V, Sánchez-Torralvo FJ, Ruiz-Vico M, González-Almendros I, Barrios M, Padín S, Alba E, Olveira G. GLIM criteria using hand grip strength adequately predict six-month mortality in cancer inpatients. Nutrients. 2019 Sep;11(9):2043.
20. Tavares GMS, Müller DVK, Fão RN, Manfredini V, Piccoli JCE. Analysis of handgrip strength and occurrence of falls in elderly women. Brazilian Journal of Science and Movement.2016; 24 (3): 19-25. DOI: 10.18511 / 0103-1716 / rbcm.v24n3p19-25
21. Montejano LR, Martínez-Alzamora N, Clemente MG, Guirao-Goris S, Ferrer-Diego RM. Predictive ability of the Mini NutritionalAssessment Short Form (MNA-SF) in a free-living elderly population: a cross-sectional study. PeerJ. 2017
22. Zanin C, Jorge MS, Knob B, Wibelinger LM, Libero GA. Força de preensão palmar em idosos: uma revisão integrativa. PAJAR-Pan American Journal of Aging Research. 2018 Sep 3;6(1):22-8.
23. Barbosa-Silva TG, Bielemann RM, Gonzalez MC, Menezes AM. Prevalence of sarcopenia among community-dwelling elderly of a medium-sized South American city: results of the COMO VAI? study. Journal of cachexia, sarcopenia and muscle. 2016 May;7(2):136-43.
24. LePage L. The Importance of Realism, Character, and Genre: How Theatre Can Support the Creation of Likeable Sociable Robots. International Journal of Social Robotics. 2020 Dec 12:1-5.
25. Pérez-Sousa MÁ, Del Pozo-Cruz J, Cano-Gutiérrez CA, Ferrebuz AJ, Sandoval-Cuellar C, Izquierdo M, Hernández-Quiñonez PA, Ramírez-Vélez R. Glucose Levels as a Mediator of the Detrimental Effect of Abdominal Obesity on Relative Handgrip Strength in Older Adults. J Clin Med. 2020 Jul 22;9(8):2323. doi: 10.3390/jcm9082323. PMID: 32707776; PMCID: PMC7464715.
26. Alqahtani, B., Alenazi, A., Alshehri, M. *et al.* Reference values and associated factors of hand grip strength in elderly Saudi population: a cross-sectional study. *BMC Geriatr.* 2019; 19:271 https://doi.org/10.1186/s12877-019-1288-7
27. Labott B, K, Bucht H, Morat M, Morat T, Donath L: Effects of Exercise Training on Handgrip Strength in Older Adults: A Meta-Analytical Review. Gerontology 2019;65:686-698. doi: 10.1159/000501203
28. Bilajac L, Juraga D, Žuljević H, Glavić MM, Vasiljev V, et al. The influence of physical Activity on handgrip strength of elderly. Arch Gerontol Geriatr Res. 2019; 4(1): 020-024. DOI: https://dx.doi.org/10.17352/aggr.000011
29. Amaral CD, Portela MC, Muniz PT, Farias ED, Araújo TS, Souza OF. Association of handgrip strength with self-reported diseases in adults in Rio Branco, Acre State, Brazil: a population-based study. Public health notebooks. 2015; 31: 1313-25.
30. Riviati N, Setiati S, Laksmi PW, Abdullah M. Factors Related with Handgrip Strength in Elderly Patients. Acta Med Indones. 2017;49(3):215-219. PMID: 29093231.