Association between aerobic capacity, grip strength and cognition function with cardiometabolic diseases risk markers and mental health in the non-institutionalized old adults: a cross-sectional analysis/ *Associação entre a capacidade aeróbia, força de preensão manual e cognição com marcadores de risco de doenças cardiometabólicas e saúde mental, em idosos não institucionalizados: uma análise transversal*

Carlos Farinha [1], Ana Maria Teixeira [1], João Serrano [2], Hélder Santos [3], Fernanda M. Silva [1], Márcio Cascante-Rusenhack [4], Paulo Luís [5] and José Pedro Ferreira [1]

University of Coimbra, Research Unit for Sport and Physical Activity (CIDAF, UID/PTD/04213/2019) [1]
Sport, Health & Exercise Research Unit (SHERU), Polytechnic Institute of Castelo Branco, 6000-266 Castelo Branco, Portugal[2]
Polytechnic of Coimbra, ESTeSC, Clinical Physiology, 5 October Street - SM Bispo, Apart 7006, 3046-854 Coimbra, Coimbra, Portugal[3]
School of Physical Education and Sports, University of Costa Rica (UCR), San José 11501-2060, Costa Rica[4]
Municipality of Sertã, 6100-738 Sertã, Portugal[5]

Abstract: The elderly population is constantly growing worldwide. One of the characteristics of aging is the decrease in functional fitness and cognitive function, leading to the appearance of cardiometabolic disorders. Methodology: The aim of this study is to verify the association between aerobic capacity, handgrip strength and cognition with risk markers for cardiometabolic diseases and mental health in community dwelling elderly. The study consists of a cross-sectional analysis of baseline data from a 28-week randomized controlled trial, with a sample of 102 participants (mean age 72.32 ± 5.25 years). The sample was evaluated for anthropometry, functional fitness, heart rate variability, carotid artery intima and mean thickness (IMT), cognitive function, mental health and biochemical markers. Correlations were evaluated using Pearson's statistical analysis and interpreted according to Cohen's (1988). Results: Statistically significant correlations were found between aerobic capacity (2m-ST) and markers of functional, cardiovascular, biochemical, cognitive function and mental health fitness. Handgrip strength (HG) was statistically significantly correlated with anthropometric measurements, various indicators of functional fitness, biochemical markers, cognitive function, and mental health variables. Finally, cognitive function (MMSE) was correlated with anthropometric measures, functional fitness, cardiovascular and biochemical markers, and mental health. These data suggest that aerobic capacity, handgrip strength and cognitive function may be hypothetically associated with cardiovascular disease risk markers.
Keywords: Aerobic capacity; hand strength; cognition; cardiometabolic risk factors; Elderly.

Resumo: A população idosa está em constante crescimento a nível mundial. Uma das caraterísticas do envelhecimento é a diminuição da aptidão funcional e função cognitiva, levando ao aparecimento de distúrbios cardiometabólicos. Metodologia: O objetivo deste estudo é verificar a associação entre a capacidade aeróbia, força de preensão manual e cognição com marcadores de risco de doenças cardiometabólicas e saúde mental, em idosos da comunidade. O estudo consiste na análise transversal dos dados de linha base de um estudo randomizado controlado de 28 semanas, sendo a amostra constituída por 102 participantes (média de idade de 72,32 ± 5,25 anos). A amostra avaliada quanto à antropometria, aptidão funcional, variabilidade da frequência cardíaca, espessura íntima e média das artérias carótidas (IMT), função cognitiva, saúde mental e marcadores bioquímicos. As correlações foram avaliadas através da análise estatística de Pearson e interpretadas de acordo com Cohen's (1988). Resultados: Foram verificadas correlações estatisticamente significativas entre a capacidade aeróbia (2m-ST) e marcadores de aptidão funcional, cardiovasculares, bioquímicos, função cognitiva e saúde mental. A força de preensão manual (HG) foi correlacionada de forma estatisticamente significativa com medidas antropométricas, vários indicadores de aptidão funcional, marcadores bioquímicos, função cognitiva e variáveis de saúde mental. Finalmente a função cognitiva (MMSE) foi correlacionada com medidas antropométricas, aptidão funcional, marcadores cardiovasculares e bioquímicos, e saúde mental. Estes dados sugerem que a capacidade aeróbia, força de preensão manual e função cognitiva podem estar hipoteticamente associadas a marcadores de risco de doenças cardiovasculares.
Palavras-chave: Capacidade aeróbia; preensão manual; cognição; fatores de risco cardiometabolico, idosos.

∗ Corresponding author e-mail address: cmnfarinha@gmail.com

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INTRODUCTION

The elderly population is in constant growth. Estimates indicate that the percentage of world population with more than 60 years of age will nearly double between 2015 and 2050, from 12% to 22% (OMS, 2018). This ageing pattern is advancing at a large rate compared to what has been previously verified. Countries now face an enormous challenge in the preparation of social and health systems to meet the needs of this demographic change (OMS, 2018).

During aging, individuals are more prone to molecular and cellular damage, which leads to the gradual advance of physical and psychological disorders. Aging also increases the occurrence of various types of diseases, such as cardiometabolic diseases, and finally to death (Lira et al., 2020; Morgan et al., 2016). A decrease in cognition levels is also present during aging, specifically in executive functions (Kirk-Sanchez & McGough, 2013). Physical function is likewise influenced by aging, more specifically with a relevant decrease in aerobic capacity (Garatachea et al., 2015), muscular strength (Dugan et al., 2018) and balance (Borges et al., 2014; Olchowik et al., 2015).

Aerobic capacity is one of the key indicators of cardiorespiratory fitness and is directly influenced by aging (Garatachea et al., 2015). The average rate of decline in the VO2 max, in the elderly population per decade, is equal to or greater than 4-5 ml/kg/min. Progressive muscular aging contributes to a reduction in the capacity of oxygen usage, which in turn is caused by: reduction of lean body mass (LBM), reduction in muscle capillary density, endothelial dysfunction, changes in skeletal muscle microcirculation, and reduced muscle oxidative capacity (Garatachea et al., 2015).

In elderly, LBM is also affected, a progressive decline in this parameter is observed after the age of 25 to 30 (Nieuwpoort et al., 2018), causing problems of functional health, independence, and reduced well-being (Stojanović et al., 2021). A progressive reduction in muscular strength can be caused by the quantitative loss of the cross-sectional area of the muscles (Garatachea et al., 2015), that is, the skeletal muscles atrophy and become progressively weaker (McPhee et al., 2016). Hand grip strength has often been applied as a general metric for whole body strength assessment (Hershkovitz et al., 2019). Lower values of hand grip strength are indicators of cardiometabolic diseases, morbidity and early mortality (Alonso et al., 2018). Reduced hand grip strength is also associated with the reduced ability to perform daily activities (Hershkovitz et al., 2019), this reduced ability leads to an increased risk of falling and to mental and depressive health problems (Fukumori et al., 2015).

Cognitive functions decline with senescence, this decline is notable in executive functions (difficulties with daily activities, slower response times, reduced information comprehension speed, decline in the realization of tasks involving exchanges of attention and decreased inhibitory control capacity) (Kirk-Sanchez & McGough, 2013). Mild cognitive impairment is considered to be the transition between a normal cognitive profile and dementia and is characterized by a greater than expected cognitive decline, without significantly affecting daily activities. In its turn dementia is characterized by a progressive and severe decline which causes loss of ability to perform activities of daily living (Karssemeijer et al., 2017).

Studies have identified correlations between aerobic capacity, muscular strength, cognition and cardiometabolic risk markers. Chong et al. (2020) verified the existence of correlations between hand grip strength, systolic and diastolic blood pressure values, BMI, protein C and diabetes levels. Other authors (Mainous et al., 2015), correlated hand grip strength with diabetic and hypertension values. Another study (Rebollo-Ramos et al., 2020), tested the correlation between aerobic fitness with different levels of adiposity, blood pressure, lipid profile, inflammatory profile (IL-6 and TNF-α) and lifestyles, in a sample with ages

⁎ Corresponding author e-mail address: cmnfarinha@gmail.com

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between 18 and 40 years. Regarding cognition Yeh et al. (2015) correlated cognitive performance with cardiometabolic variables and hyper white matter intensities, in individuals aged between 50 and 85 years. Furtado et al. (2020), tested the association between frailty and several geriatric characteristics in a group of institutionalized women aged between 75 and 85 years. In the study (Chupel et al., 2017), significant correlations were found between the Mini Mental State Examination (MMSE) test score and the 8-foot up and go test (8-foot) and chair stand test (30s-CS) in a group of old women (82.7 ± 5.7 years) with moderate cognitive impairment. In the same direction, the study (Furtado et al., 2017), correlations were found between indicators of physical fragility and the 8-foot (positive strong), the 30s-CS and arm curl test (30s-AC) (negative moderate) and no correlation was found between frailty indicators and body mass índex (BMI) in a sample of 119 women (81.96 ± 7.89 years).

Despite being a topic that is frequently addressed in current literature, a lack of studies of the aforementioned associations in the community dwelling elderly is notable (Aparicio et al., 2017; Hernandez-Martinez et al., 2019; Lee et al., 2016; Tay et al., 2019). Therefore, the necessity of conducting more studies that use as a basis community dwelling elderly is of importance. These studies aid in discovering evidence that support the efficiency of using aerobic capacity, grip strength and cognition in preventing cardiometabolic diseases.

The purpose of this study is to investigate the association between the aerobic capacity, hand grip strength and cognition with a wide range of cardiometabolic markers (anthropometry, physical function, immunological markers and cardiovascular markers) and mental health, in community dwelling elderly.

METHODS

Study design

Participants in this study are part of the sample of the study protocol published by Ferreira et al. (2020). The present study consists of a cross-sectional analysis of baseline data collected from 28 weeks randomized and controlled intervention study with physical exercise in aquatic environment with elderly aged equal to or above 65 years old, living in Sertã region, Centre of Portugal. All participants attended a community aquatic physical exercise program ran by the Municipality of Sertã in the local swimming pool. This was an exploratory case-control, local, population-based survey (Pearce, 2012) that collected information on the effects of different aquatic exercise programs on anthropometrics, physical function, cognitive function, mental health, heart rate variability, carotid arteries intima-media thickness, and biochemical markers in community dwelling elderly. In addition, this study was designed to provide information on the trends and results expected when using a representative probabilistic sample of this population in future studies.

Sample selection criteria

The participants were recruited with a non-probability convenience sampling method in the central area of Portugal (Sertã). The sample size was calculated using G-Power software (Effect size: 0.25; α-level: 0.05; power: 0.95; n=76). The following eligibility criteria was used to form the sample: a) both female and male individuals; b) age equal to or above 65 years; c) community dwelling elderly; d) ability of participants to autonomously travel from there residence to Sertã municipal pool. Furthermore, ineligible criteria were also defined: a) individuals with medically diagnosed pathologies that jeopardize their health while preforming aquatic based exercises; b) severe cognitive impairment, that is, a score below 9 in the Mini

⁎ Corresponding author e-mail address: cmnfarinha@gmail.com

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Mental States Examination or a clinically diagnosed mental illness. After applying the previously mentioned eligibility and ineligible criteria, the final sample was composed of 102 individuals (24 male and 78 female) with a average age of 72,32 ± 5,25 years.

Ethical aspects

All participants or their legal representatives signed consent forms. The study protocol was approved by the Ethical Committee of the Faculty of Sport Science and Physical Education at University of Coimbra (Reference code CE/FCDEF-UC/00462019) and previously published (Ferreira et al., 2020). The study protocol respected the Portuguese Resolution (Art. 4th; Law n° 12/2005, 1st series) and complied with research guidelines in humans of the Helsinki Declaration (Petrini, 2014).

Data collected is confidential and used exclusively for scientific investigation purposes, obeying all the anonymization procedures defined by the Data Projection Regulation, applied since May 25, 2018.

Assessment instruments

Blood samples were drawn at a professional clinic using certified methods (Clinic-Affidea Sertã). The carotid arteries intima-media thickness assessment was conducted by a cardiology specialist. The rest of the data was collected and organized by members of the research team. Data quality was assessed using internal consistency reliability (ICR) measure.

Anthropometry measurements

Anthropometry measurements were conducted by a certified investigators by FCDEF-UC. The following parameters were assessed: height (Hgt), evaluated with a portable stadiometer, Seca Bodymeter® (model 208, Germany), with a precision of 0.1 cm; weight (Wgt), body mass index (BMI), visceral fat (VF), percentage of fat mass (FM) and muscle body mass (LBM) using a portable scale TANITA BC-601 with a precision of 0.1 cm with 0.1 kg accuracy; and waist circumference (WCir), arms (ACir) and legs (LCir) were measured using a retractable fiberglass tape (model Hoechstmass-Rollfix®, Germany) with an accuracy of 0.1 cm.

Physical Function

Physical Function was assessed with the Senior Fitness Test Battery (Rikli & Jones, 1999), validated for the Portuguese population by Baptista and Sardinha (2005). Lower body muscular strength was evaluated with the chair stand test (30s-CS) (repetitions/30s); Upper body strength was evaluated with the arm curl test (30s-AC) (repetitions/30s); aerobic capacity was assessed with the two-minutes step test (2m-ST) (repetitions /2min); Lower body flexibility was measured with the chair sit and reach (CSR) (centimetres) and upper body flexibility was assessed with the back scratch test (BS) (centimetres); agility and dynamic balance was assessed via the timed up and go test (TUG) (seconds); and hand grip strength was evaluated with the hand grip test (HG) (kg).

Cognitive function and mental health

Cognitive function was calculated with the Portuguese version of the Mini Mental State Examination - MMSE (Morgado et al., 2009), which evaluates the following areas of cognition: orientation, short term memory, attention and calculation capacities, and long term memory and language aptitudes. The final score has a maximum of 30 points, and scores below 24 can be used as an aid in the assessment of

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dementia. The test will be used as an instrument to create a cognitive profile with the following criterium (Mungas, 1991): severe cognitive impairment (scores between 1 and 9 points); moderate cognitive impairment (scores between 10 and 18 points); mild impairment (score between 19 and 24 points), normal cognitive profile (scores between 25 and 30 points).

Mental health was assessed with following questionnaires and scales validated for the Portuguese population: Rosenberg Self-Esteem Scale – RSES (Neto, 1996), which assess global self-esteem; Physical Self-Perception Profile For Clinical Populations – CPSPP (Ferreira et al., 2017), which is a self-assessment of physical characteristics in elderly groups and is composed of the following dimensions: functionality, physical health, sports competence, body attraction, physical strength and physical self-worth; World Health Organization Well-Being Index - WHO5 (Canavarro et al., 2009), which gauges psychological well-being; Satisfaction With Life Scale – SWLS (Neto & Oliveira, 2004), which evaluates global cognitive parameters of life satisfaction; EuroQol – EQ5D (Ferreira et al., 2013), which assess the general health of the participants; Geriatric Depression Scale - GDS (Apóstolo et al., 2014), assess life satisfaction, interruptions in activities, annoyances, isolation, energy, joy and memory problems; Perceived Stress Scale - PSS (Trujillo & Cabrera, 2007), used to measure perception of stress.

<u>The carotid arteries intima-media thickness (IMT)</u>

The (right and left) IMT was measured with a portable Doppler ultrasound of make and model General Electric VIDe® with an 11L probe, using the AIRC Study protocol (Stein et al., 2008). The measurements consisted of the following parameters: Intima-media thickness (IMT); systolic diameter (SD); diastolic diameter (DD); peak systolic velocity (PSV); end-diastolic velocity (EDV). Heart rate (HR), systolic blood pressure (SBP) and diastolic blood pressure (DBP) values were also evaluated with a RI-Champion N® sphygmomanometer.

<u>Heart rate variability (HRV)</u>

HRV was assessed by following the procedures devised by Abad et al. (2017). Polar V800 (Polar Electro Oy, Finland) heart rate monitors were used, for 10 minutes, with the participants in a calm, silent and low light environment. The following values will be recorded: minimum R-R interval (RRmin); maximum R-R interval (RRmax); mean R-R range (RRmean); Root mean square of the successive normal sinus R-R-interval difference (RMSSD).

<u>Biochemical markers</u>

Blood samples were drawn via venepuncture, with 12 hour fasting participants. The following parameters were evaluated: HDL cholesterol (HDL), LDL cholesterol (LDL), cholesterol total (CLT), glucose (GLU), triglycerides (TRI), leukocytes (LEU), lymphocytes (LI), monocytes (Mo), red blood cells (RBCs), erythrocytes (ERI), hemoglobin concentration (Hb), hematocrit (Hct), mean corpuscular volume (MCV), mean globular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), erythrocytes distribution width (RDW), platelets (PL), mean platelet volume (MPV), procalcitonin (Pct), adenosine diphosphate (ADP), using an automatic hematologic analyser Coulter Act Diff, Beckman Coulter, USA; Levels of interleukin 10 (IL-10), interleukin 1 (IL-1ra), interleukin 1 beta (IL-1β) and tumor necrosis factor (TNF-α) were also analysed with ELISA Invitrogen® CA kits.

Data analysis

* Corresponding author e-mail address: cmnfarinha@gmail.com

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The collected data was subject to descriptive statistical analysis, were values such as maximum, minimum, mean and standard deviation were calculated for each variable. Afterward, data normality was tested considering the response to 3 conditions: z-values from Skewness and Kutosis tests; p value from Shapiro-Wilk test; and histogram redundancy. Statistical tests, Pearson's r-moment and Spearman's r-product correlation tests were applied to the data to establish the relationship between the different variables under study. Relationship between the different variables were interpreted according to Cohen's (1988) cutoff values which consider that r = -/+.10 to -/+ .29 means weak correlation, r = -/+.30 to -/+ .49 means moderate correlation and r = -/+.50 to -/+ 1.0 means strong correlation.

The whole statistical analysis was performed using version 26.0 of the statistical software, Statistical Package for the Social Sciences (SPSS), with a level of significance of p ≤ 0.05.

RESULTS

The sample was composed of 102 community dwelling elderly, with a mean age of 72.32 ± 5.25 years, 24 males (mean age 74.00 ± 4.39) and 78 females (mean age 71.81 ± 5.40). The short query answers revealed that 95 % of the participants used medication (MED) in a regular basis, 61% mentioned not to have any allergies (ALL), 41% responded that they attended a doctor (VDY) in average 3 or more times a year, 49% classified their sleep (SQ) as being good. The participant´s anthropometric characteristics are presented in Table 1.

Table 1 - Participant´s anthropometric profile characterization analyzed by gender

	All sample (N=102)							
	Female (N=78)				Male (N=24)			
	Minimum	Maximum	Mean	Std. Dev.	Minimum	Maximum	Mean	Std. Dev.
Age	65	86	71.81	5.40	65	82	74.00	4.39
Hgt (cm)	1.47	1.66	1.54	0.04	1.59	1.76	1.67	0.05
Wgt (kg)	49.4	104.3	71.23	11.96	63.9	97.7	78.82	9.97
BMI (kg/m²)	20.7	42.9	29.92	5.07	20.5	38.0	27.98	3.76
VF (%)	6	18	11.59	2.90	14	28	14.58	5.20
FM (%)	27.4	57.1	42.73	6.26	11.5	33.8	27.22	4.73
LBM (%)	18.4	41.0	24.32	3.33	26.8	37.5	30.97	2.15

Note: Height (HGT); Weight (Wgt); Body mass index (BMI); Visceral fat (VF); Fat mass (FM); Lean body mass (LBM).

In terms of aerobic capacity, the final mean result for the study sample was 77,22. The relationship between aerobic capacity and the different variables assessed in the present study (anthropometry, physical function, cognitive function, mental health, immunological markers and cardiovascular markers) showed a strong and positive correlation between the 2m-ST variable and the 30s-CS (r=.562; n=102; *p*<0.001); 30s-AC (r=.513; n=102; *p*<0.001); and a strong and negative correlation with the TUG variable (r=-.591;

⁎ Corresponding author e-mail address: cmnfarinha@gmail.com
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n=102; *p*<0.001). There was a moderate and positive correlation between the 2m-ST variable and the HG (r=.426; n=102; *p*<0.001), EDV–R (r=.326; n=102; *p*=.001), SWLS (r=.314; n=102; *p*=.001), and EQ5D – scale (r=.394; n=102; *p*<0.001). Finally, there was a weak and positive correlation between the aerobic capacity variable and CSR–L (r=.198; n=102; *p*=.046); BS–R (r=.212; n=102; *p*=.032); BS–L (r=.230; n=102; *p*=.020); EDV–L (r=.232; n=102; *p*=.019); PSV–R (r=.248; n=102; *p*=.012); TNF-α (r=.210; n=102; *p*=.034); LI (r=.286; n=102; *p*=.004); and MMSE (r=.275; n=102; *p*=.005). There was a weak and negative correlation between the 2m-ST variable and the IMT–R (r=-.271; n=102; *p*=.006), GR (r=-.287; n=102; *p*=.003) and GDS (r=-.291; n=102; *p*=.003). These results are presented in Figure 1 and 2.

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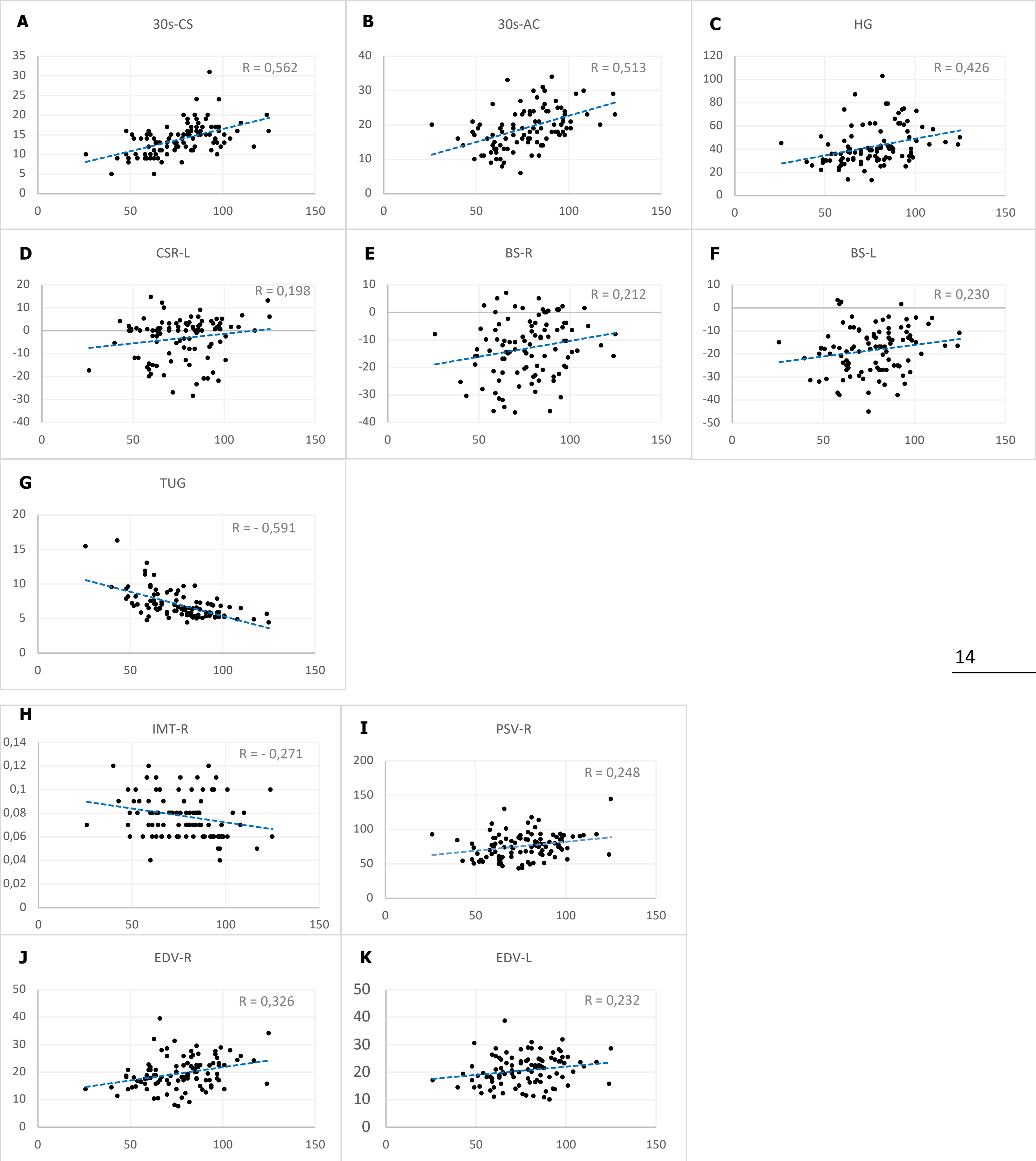

Figure 1 - Relationship between aerobic capacity variable assessed through the 2m-ST and chair stand test (30s-CS) (A), arm curl test (30s-AC) (B), hand grip test (HG) (C), chair sit and reach test (CSR) (D), back scratch test - right (BS-R) (E), back scratch test – left (BS-L) (F), timed up and go test (TUG) (G), intima-media thickness (IMT) (H),peak systolic velocity (PSV) (I), end-diastolic velocity – right (EDV-R) (J) and end-diastolic velocity – left (EDV-L) (K).

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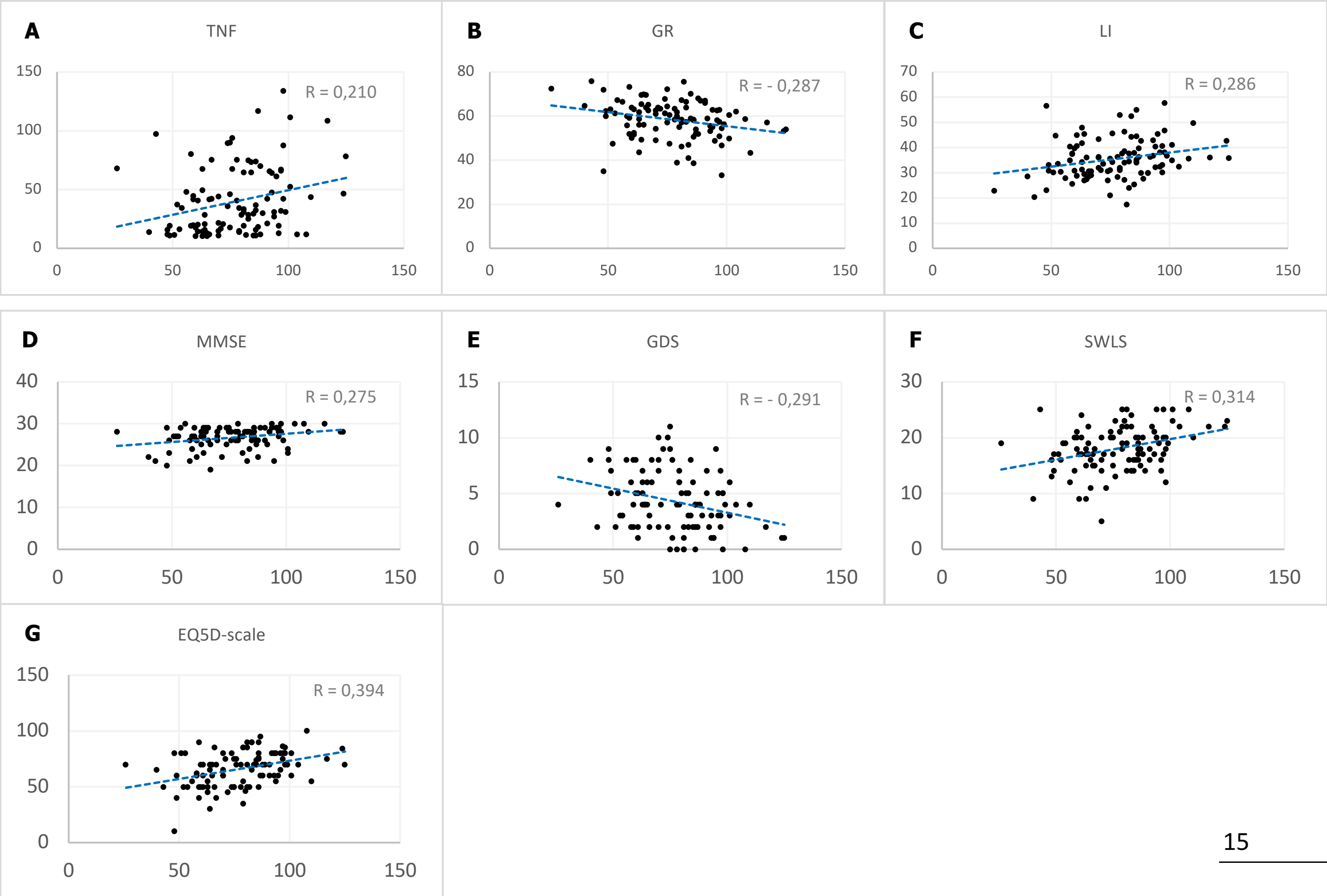

Figure 2 - Relationship between aerobic capacity variable assessed through the 2m-ST and tumor necrosis factor (TNF-α) (A), granulocytes (GR) (B), lymphocytes (LI) (C), mini mental state examination (MMSE) (D), geriatric depression scale (GDS) (E), satisfaction with life scale (SWLS) (F) and euroqol (EQ5D) (G).

In relation to handgrip strength, the final mean result for the study sample was 42kg. Value was calculated according to the sum of the two best results from the HG from both hands (ACSM, 2018). The relationship between hand grip test (HG) and the different variables assessed in the present study (anthropometry, physical function, cognitive function, mental health, immunological markers and cardiovascular markers) showed a strong and positive correlation between the HG variable and the Hgt (r=.522; n=102; *p*<0.001). There was a moderate and positive correlation between the HG variable and LBM (r=.381; n=102; *p*<0.001), 2m-ST (r=.426; n=102; *p*<0.001), 30s-AC (r=.365; n=102; *p*<0.001), and MMSE (r=.342; n=102; *p*<0.001). There was a moderate and negative correlation between the HG variable and FM (r=-.348; n=102; *p*<0.001) and TUG (r=-.403; n=102; *p*<0.001). Finally, there was a weak and positive correlation between the HG variable and Wgt (r=.253; n=102; p=.010); 30s-CS (r=.289; n=102; p=.003); ERI (r=.233; n=102; p=.018); Hb (r=.270; n=102; p=.006); Hct (r=.275; n=102; p=.005); RSES (r=.233; n=102; p=.019); and EQ5D–scale (r=.217; n=102; p=.028). There was a weak and negative correlation between GLU (r=-.197; n=102; p=.047); CLT (r=-.255; n=102; p=.010); HDL (r=-.285; n=102; p=.004); GDS (r=-.290; n=102; p=.003); and PSS (r=-.239; n=102; p=.015). These results are presented in Figure 3 and 4.

⁎ Corresponding author e-mail address: cmnfarinha@gmail.com
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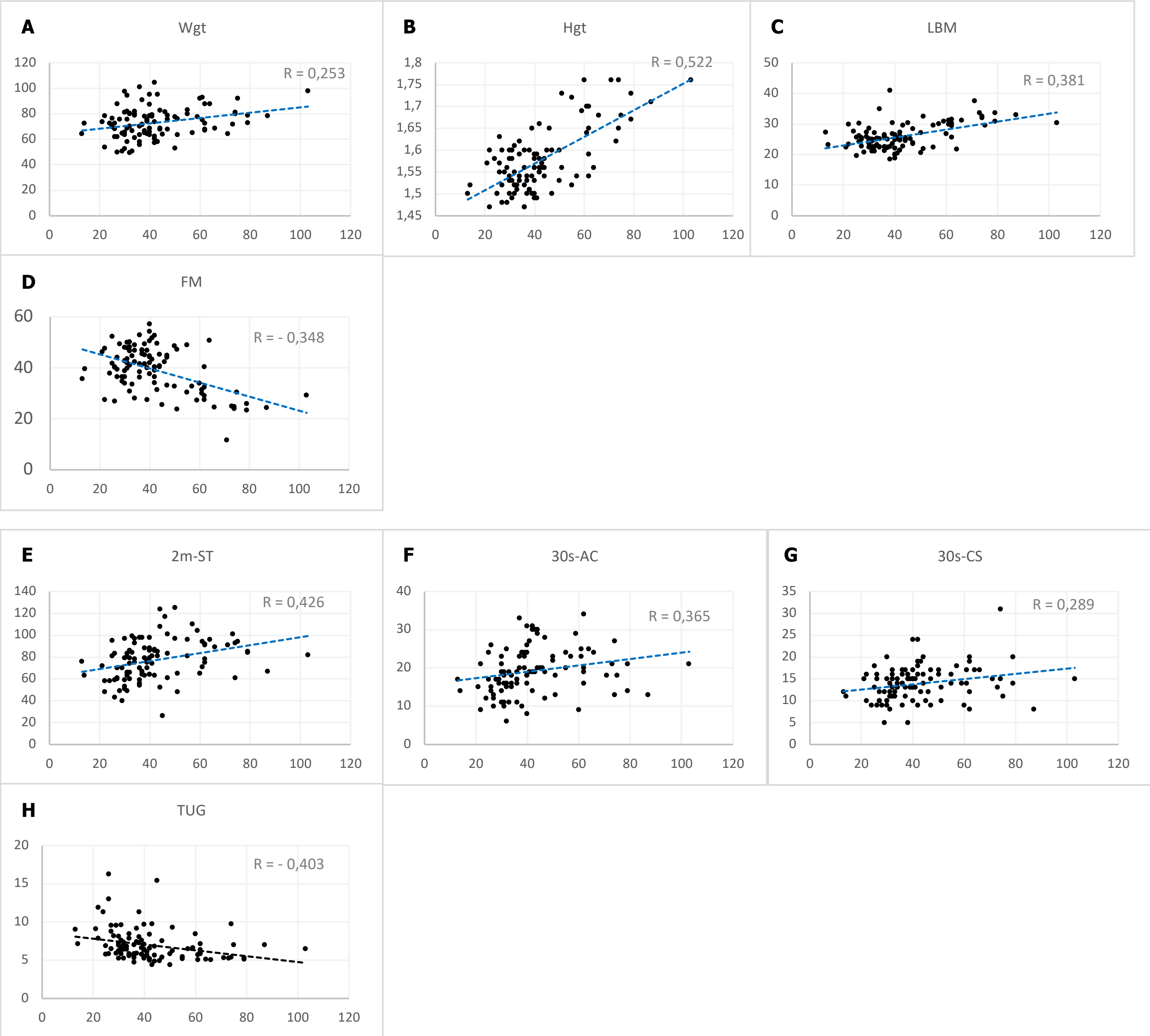

Figure 3 - Relationship between hand grip strength assessed through the HG and weight (Wgt) (A), height (Hgt) (B), muscle mass (LBM) (C), fat mass (FM) (D), two-minutes step test (2m-ST) (E), arm curl test (30s-AC) (F), chair stand test (30s-CS) (G) and timed up and go test (TUG) (H).

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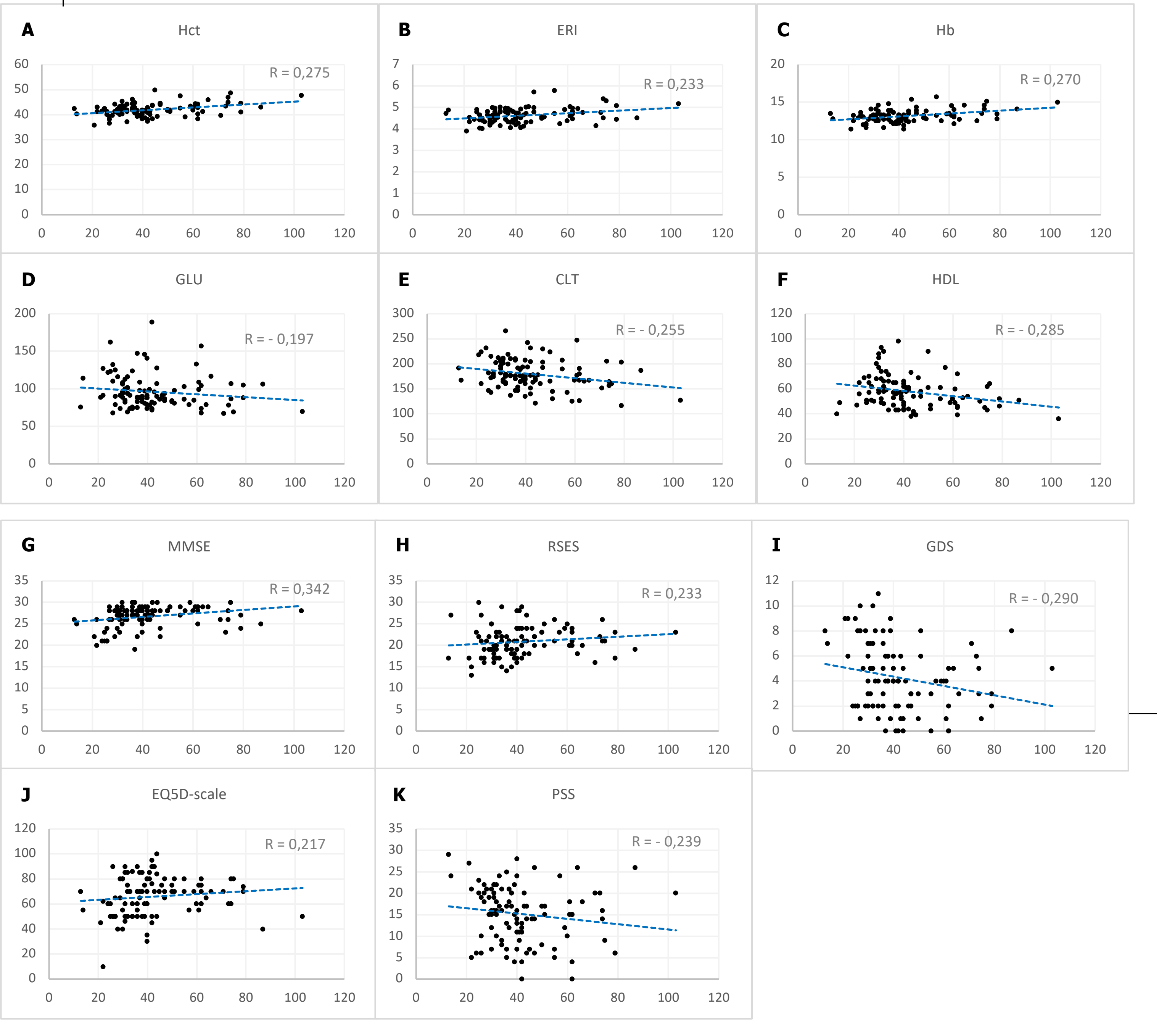

Figure 4 - Relationship between hand grip strength assessed through the HG and hematocrit (Hct) (A), erythrocytes (ERI) (B), hemoglobin concentration (Hb) (C), glucose (GLU) (D), cholesterol total (CLT) (E), high-density lipoprotein (HDL) (F), mini mental state examination (MMSE) (G), rosenberg self-esteem scale (RSES) (H), geriatric depression scale (GDS) (I), euroqol (EQ5D) (J) and perceived stress scale (PSS) (K).

⁎ Corresponding author e-mail address: cmnfarinha@gmail.com

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Finally, cognitive function was assessed using the MMSE, with the total sample achieving an average score equivalent of 26.71 points, being considered as a normal cognitive profile (Mungas, 1991). The relationship between cognitive function assessed using the MMSE score and the different variables assessed in the present study (anthropometry, physical function, cognitive function, mental health, immunological markers and cardiovascular markers) revealed a moderate and positive correlation between HG (r=.342; n=102; p<0.001), EQ5D–scale (r=.307; n=102; p=.002), and a moderate and negative between TUG (r=-.300; n=102; p=.002). Finally, there was a weak and positive correlation between LCir–R (r=.247; n=102; p=.012); LCir–L (r=.222; n=102; p=.025); 2m-ST (r=.275; n=102; p=.005); BS–R (r=.210; n=102; p=.035); 30s-CS (r=.194; n=102; p=.050); and 30s-AC (r=.253; n=102; p=.010). There was also a weak and negative correlation between IMT–L (r=-.213; n=102; p=.031), ADP (r=-.208; n=102; p=.036) and GDS (r=-.201; n=102; p=.043). These results are presented in Figure 5.

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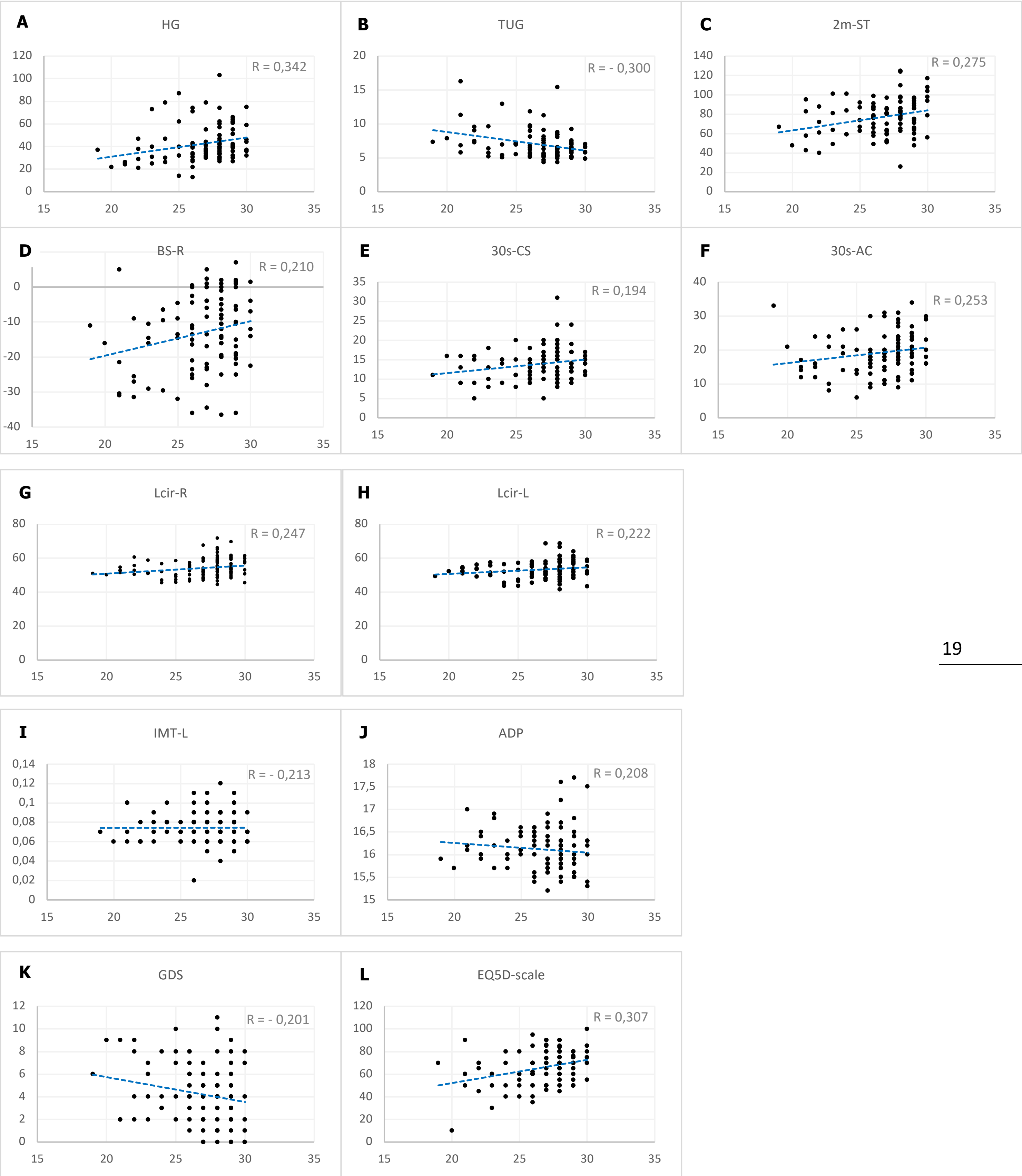

Figure 5 - Relationship between cognitive function assessed through the MMSE and hand grip test (HG) (A), timed up and go test (TUG) (B), two-minutes steo test (2m-ST) (C), back scratch test – right (BS-R) (D), chair stand test (30s-CS) (E), arm curl test (30s-AC) (F), legs circumference – right (LCir-R) (G), legs circumference – left (LCir-L) (H), intima-media thickness (IMT) (I), adenosine diphosphate (ADP) (J), geriatric depression scale (GDS) (K) and euroqol (EQ5D) (L).

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DISCUSSION

The purpose of this study was investigate the association between the aerobic capacity, hand grip strength and cognition with a wide range of cardiometabolic markers (anthropometry, physical function, immunological markers and cardiovascular markers) and mental health, in community dwelling elderly.

The results of this study suggesting a strong positive correlation between aerobic fitness (assessed by 2m-ST) and 30s-CS and 30s-AC, and a strong negative correlation between TG. A moderate positive correlation between 2m-ST and HG, EVD-R, SWLS and EQ5D-scale. A weak positive correlation between 2m-ST and CSR-L, BS-R, BS-L, EDV-L, PSV-R, TNF-α, LI and MMSE, and a weak negative correlation between IMT-R, GR and GDS.

Our results are in agreement with those found in other studies. Regarding physical function, Teodorczyk et al. (2016) also demonstrated a strong and positive correlation between aerobic capacity and lower limb muscle strength, assessed using an isometric dynamometer armchair. Likewise, in the study of Kaymaz et al. (2018), positive and moderate correlations were also found between aerobic capacity (i.e., assessed through the incremental back-and-forth walk test and through the resistance walk test) and upper limb muscle strength (i.e., assessed through the one-repetition maximal test for the upper limb strength). Pedrosa and Holanda (2009) demonstrated a strong and negative correlation between aerobic capacity and agility/dynamic balance. Similarly, Taylor-Piliae et al. (2012) also found a moderate and positive correlation between aerobic capacity with lower limb strength, and with balance (i.e., assessed using the unipedal stance test). Katsimpris et al. (2021) demonstrated a strong and positive correlation between aerobic capacity and handgrip strength. Regarding flexibility, in the study of Chang et al. (2019) a moderate and positive correlation was verified between aerobic capacity and flexibility (back-scratch test). However, in studies of Santos et al. (2018) e Huang et al. (2018), no statistically significant correlations were found between these two variables.

Other studies have also verified the association between aerobic capacity and the intima and media thickness of the carotid arteries. In particular, the study of Lee et al. (2009) which demonstrated a strong and negative association between aerobic capacity and the risk of developing carotid atherosclerosis, and the study of J. Lee et al. (2019), which also demonstrated an inverse association between aerobic capacity and the development of carotid artery disease and with the intima and medium thickness of the carotid arteries.

As for biochemical markers, in the study of Lacedonia et al. (2016) there was also a moderate and negative correlation between aerobic capacity (6-minute walking test) and granulocyte levels. Contrary to the results found in the present study, Pérez & Núñez (2018), found a weak and negative correlation between aerobic capacity and the TNF-α marker. In the study of Neves et al. (2021), there was also a moderate and negative correlation between these two variables. Likewise, the results of Okan (2020) showed a negative correlation between aerobic capacity (6-minute walking test) and the neutrophil/lymphocyte ratio.

Regarding psychological health, studies of Marques et al. (2017) e Kouwijzer et al. (2020), also showed a moderate and positive relationship between aerobic capacity and life satisfaction. In the study of Kim et al. (2019) a moderate and positive correlation was found between aerobic capacity and quality of life. And in the study of Baldasseroni et al. (2014), a moderate and negative correlation was found between aerobic capacity and the geriatric depression scale. As for the cognitive level, the study of Yazar et al. (2018),

* Corresponding author e-mail address: cmnfarinha@gmail.com
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showed a moderate and positive correlation between aerobic capacity (6-minute walking test) and the MMSE.

The 2m ST is considered an adequate tool to assess aerobic fitness, as it has minimal requirements that make it easy to apply to different study scenarios (Ricci et al., 2019). Our results reinforce the importance of improving aerobic capacity, which is an important component that can significantly improve the predictive ability of cardiovascular disease risk in both the short and long term (Lin et al., 2015). According to the same authors, aerobic capacity is an indicator used in clinical practice, both in the diagnosis and prognosis of cardiovascular diseases.

Regarding muscle strength, we verified the strong positive correlation between HG and Hgt. A moderate positive correlation between HG and LBM, 2m-ST, 30s-AC and MMSE, and a moderate negative correlation between HG and FM and TUG. A weak positive correlation between HG and Wgt, 30s-CS, ERI, Hb, Hct, RSES and EQ5D, and weak negative correlation between GLU, CLT, HDL, GDS and PSS.

The obtained results are aligned with those found in the literature. Regarding body composition, Torralvo et al. (2018) also demonstrated a strong and positive correlation between handgrip strength and height. However, in the study of Pizzigalli et al. (2017) this correlation was moderate and positive. Buehring et al. (2018) also demonstrated a moderate and positive correlation between handgrip strength and muscle mass, assessed by different methods (i.e., dual-energy X-ray asborptiometry, bioelectric impedance and creatine dilution DB-CR), e Torralvo et al. (2018) demonstrated a strong and positive correlation between handgrip strength and muscle mass (i.e., bioelectric impedance). Torralvo et al. (2018) also demonstrated a strong and negative correlation between handgrip strength and fat mass. However, in the study of Bentes et al. (2017), there were no statistically significant correlations between handgrip strength and weight.

Regarding functional fitness, Katsimpris et al. (2021) also demonstrated a strong and positive correlation between handgrip strength and aerobic capacity. Alonso et al. (2018) demonstrated a moderate and positive correlation between handgrip strength and lower limb muscle strength. C. Liu et al. (2017), also demonstrated a moderate and positive relationship between HG and upper limb muscle strength. (30s-AC). Lam et al. (2016) e Alonso et al. (2018) demonstrated a weak and negative correlation between handgrip strength and agility and dynamic balance (i.e., TUG).

At the immunological level, in the study of Belury et al. (2021), ERI values were also positively associated with handgrip strength. Hu et al. (2018) demonstrated a positive correlation between handgrip strength and Hb levels. in the same sense, Sayre et al. (2017) demonstrated a positive association between HG and Hb and Hct levels. In the lipid profile, blood glucose values were negatively associated with HG, that is, participants with higher blood glucose levels had a lower result in HG (Åström et al., 2021; Liang et al., 2020) and Pedrero-Chamizo et al. (2020) found a weak and negative correlation between HG and total cholesterol. In HDL levels, the same authors found a weak and positive correlation with HG, contradicting the results verified in the present study.

In terms of cognitive function and mental health, our study found a statistically significant correlation between HG and cognitive function, quality of life, level of depression and perceived stress. In the study of Y. Liu et al. (2021), the results also showed a weak and positive correlation between handgrip and cognitive level (i.e., MMSE). However, such association was not found in previous studies (Chupel et al., 2017) assessing the same variables in elderly participants. in the study of Hu et al. (2018), the results also showed a positive association between handgrip strength and quality of life. Ozer et al. (2021) showed a weak and negative correlation between the HG and the Geriatric Depression Scale, in participants aged over 60 years. in the study of Poornima et al. (2014), the results also showed a weak and negative correlation between

⁎ Corresponding author e-mail address: cmnfarinha@gmail.com

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handgrip strength and perceived stress (assessed using the PSS). Additionally, in our study, a statistically significant correlation was found between HG and self-storage (assessed using the Rosenberg scale). No other studies were found where this correlation was verified.

These results are relevant since reduced muscular strength, in the elderly, impacts everyday tasks. A significant increase in the risk of falling and loss of functional independence is also associated with muscular strength reduction (Alonso et al., 2018). Hand grip strength is fast and simple to assess. It has been considered as an important clinical test to be used to identify increased risk of morbidity and mortality (Hershkovitz et al., 2019; Wu et al., 2019). Hand grip strength is often used in the detection of deteriorations related to aging and is observed in the LBM and strength (McGrath et al., 2018) parameters.

Regarding cognition function, we verified the moderate positive correlation between MMSE and HG and EQ5D-scale, and a moderate negative correlation between MMSE and TUG. A weak positive correlation between MMSE and LCir-R, LCir-L, 2m-ST, BS-R, 30s-CS and 30s-AC, and weak negative correlation between IMT-L, ADP and GDS.

The results obtained are in line with those found in other studies. With regard to functional fitness, Y. Liu et al. (2021) and Ramnath et al. (2018) also demonstrated a moderate and positive correlation between cognitive fitness and handgrip strength. However, Emerenziani et al. (2020) had already demonstrated a strong and positive correlation between these two variables. n the study of Chupel et al. (2017), moderate and negative correlations were also demonstrated between cognitive aptitude and agility/dynamic balance. In the same vein, in the study of Borges et al. (2018) a weak and negative correlation was shown between cognition and agility/dynamic balance while, in the study of Ramnath et al. (2018), there were no significant correlations between the two variables. Still in functional fitness, Chupel et al. (2017), also found moderate positive associations between MMSE and upper and lower strength (30s-CS and 30s-AC), and cardiorespiratory fitness (2m-ST), in institutionalized elderly. According to the authors, these associations can be explained by ascertaining that physical fitness tests involve, in addition to physical requirements, some attention, concentration and understanding from the perspective of the participants. Similarly, Yang et al. (2018) presented the correlation that lower and upper limb strength, lower limb flexibility, dynamic agility/balance and aerobic capacity are independently associated with cognitive function. According to the authors, little is known about the mechanisms between cognitive and physical functions. However, physical fitness tests require refined brain control mechanisms to start tasks, in addition to motor unit recruitment and motor coordination. Similarly, Yang et al. (2018) also showed that participants with cognitive impairment scored lower on several tests of functional fitness (30s-CS, 30s-AC, 2m-ST, CSR and BS).

In relation to the intima and mean thickness of the carotid arteries, our results are in agreement with those found in the study by Yue et al. (2016), where they demonstrated that participants with cognitive impairment had a higher IMT value, compared to participants with a normal cognitive level. This result reinforces the results of the study by Gorgone et al. (2009), that found a moderate and negative correlation between the MMSE and the IMT.

Regarding the relationship between cognitive functions and mental health, our results are supported by the study by Chae et al. (2020), where a lower score on the Quality of Life questionnaire was associated with a cognitive decline (MMSE), suggesting that quality of life metrics should be used as a tool to detect cognitive changes in the elderly, and thus prevent or delay cognitive decline. Similarly, Samuel et al. (2016) concluded that compromised cognitive function, in the elderly, has a negative effect on health-related quality of life metrics, regardless of gender, education or the existence of chronic illnesses. On the other hand, in the study by Voros et al. (2020), no significant associations were found between elderly cognitive function

⁎ Corresponding author e-mail address: cmnfarinha@gmail.com

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(assessed using the MMSE) and quality of life (Older People Quality of Life questionnaire). As in our study, Ozer et al. (2021) also demonstrated a weak and negative correlation between the MMSE and the GDS.

Additionally, in our study, a statistically significant correlation was found between MMSE and the variables ADP, LCir-R and LCir-L. No other studies were found where these correlations were verified. These data suggest that cognitive function can also influence the immune profile and body composition, more precisely the perimeters of the lower limbs.

Cognitive function assessment has considerable scientific value. With aging, a decline in cognition is observed. This decline originates in the expansion of cerebral spinal fluid, in the progressive deterioration of the microstructure of white matter and other subcortical nuclei (hippocampus, cerebellum and striatum) (Cherup et al., 2018).

The results found in the present study showed that aerobic capacity (2m-ST), handgrip strength (HG) and cognitive function (MMSE) can be correlated with a wide range of cardiometabolic markers. More studies are needed to corroborate the evidence found. It is also relevant to develop more studies that test interventions that can improve these markers, such as exercise in an aquatic environment.

CONCLUSION

Our results suggest that aerobic capacity (assessed using 2m-ST) may be related to functional fitness, cardiovascular, biochemical, cognition and mental health markers. They also suggest that handgrip strength (assessed using the GH) may be correlated with anthropometric measurements, functional and biochemical fitness markers, with cognitive function and mental health. Regarding cognitive function (MMSE), the results suggested that it may be associated with anthropometric measures, functional fitness, cardiovascular and biochemical markers, and also with mental health. These data show that aerobic capacity, handgrip strength and cognitive function may hypothetically be related to risk markers for cardiometabolic diseases.

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⁎ Corresponding author e-mail address: cmnfarinha@gmail.com

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⁎ Corresponding author e-mail address: cmnfarinha@gmail.com

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∗ Corresponding author e-mail address: cmnfarinha@gmail.com

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* Corresponding author e-mail address: cmnfarinha@gmail.com

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⁎ Corresponding author e-mail address: cmnfarinha@gmail.com

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⁎ Corresponding author e-mail address: cmnfarinha@gmail.com

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