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The influence of winter and summer seasons on physical fitness in aged population

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ABSTRACT

Epidemiological studies have described the association between physical fitness and health. Few have reported the impact of seasonal variation on fitness determinants, in elderly. We investigated the effects of summer and winter environmental conditions on physical fitness, in both exercise and non-exercise elders. 371 non-institutionalized older adults (74.1% female; 78.4 ± 5.3 years) randomly recruited from a total sample of 1338 subjects from north of Portugal, were prospectively followed during 1 year and 3 assessments were performed – April (baseline), October (summer season) and April (winter season). Four groups were defined, according to reported habits of exercising: Exercise (EG); Winter Exercise (WG); and Summer Exercise (SG); non-Exercise (nEG). Muscle strength was assessed with handgrip and isometric knee extension test, and aerobic capacity with the 6 min walking test. Repeated measures ANOVA with two between-subjects factors were run for independent variables, considering a three Time points. Significance set at $p < .05$. Findings show that: (1) men were fitter than women; (2) EG showed better results than nEG ($p = .000$), but not different than WG or SG, (3) nEG physical fitness was not significantly different from WG and SG; (4) SG and WG showed similar results; (5) there was significant group-by-time interaction for all variables in study. Among elderly, the regular physical exercise determined better cardiorespiratory fitness and levels of strength compared to individuals that were not exercising, however, no season impact was observed. Independently of exercising mode, regular, seasonal or not exercising, the pattern of changes in physical fitness throughout the year was similar.

1. Introduction

The age-related decline in physical fitness in aged population is well reported in literature (Ribom, Mellstrom, Ljunggren, & Karlsson, 2011; Rikli & Jones, 2013). By the fifth decade, similarly to the muscle mass decline, the losing in muscle strength occurs at steady decline rates of approximately 1–2% per year (Vandervoort, 2002). The deterioration on physical fitness seems to contribute to rising morbidity and mortality rates (Paterson & Warburton, 2010).

Previous longitudinal studies have reported the effectiveness of the intervention programs in maintaining quality of life (Blain et al., 2012). For example, exercise intervention programs applying to muscle strength (Geirsdottir et al., 2012; Seguin, Heidkamp-Young, Kuder, & Nelson, 2012), aerobic training (Halloway, Wilbur, Schoeny, Semanik, & Marquez, 2015), or both (Cadore et al., 2014), have been reported as successful contributors for improving physical fitness. Furthermore, intervention programs including different exercise type as Tai Chi (Callahan, Cleveland, Altpeter, & Hackney, 2015) or Pilates (Geremia, Iskiewicz, Marschner, Lehnen, & Lehnen, 2015), have shown important and positive output on the physical fitness of aged population, comparatively to their not exercising counterparts.

Daily conditions were find to modify customary physical activity and daily routines (Kristal-Boneh, Froom, Harari, Malik, & Ribak, 2000; Merrill, Shields, White, & Druce, 2005). Results show that elderly took a higher amount of steps in summer comparatively to winter season (Clemes, Hamilton, & Griffiths, 2011), and that levels of physical activity vary with seasonality, being the poor or extreme weather a barrier to participation in physical activity with a possible negative impact physical fitness (Tucker & Gilliland, 2007). In fact, little is known about the impact of winter and summer seasonal variations conditions in physical fitness of aged population (Clemes et al., 2011; McCormack, Friedenreich, Shiell, Giles-Corti, & Doyle-Baker, 2010). Therefore, the aim of this study was to investigate the effects of summer and winter seasonal conditions on the physical fitness in both, exercise and non-

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exercise aged population.

2. Methods

This study was a 12 months longitudinal design involving aged population. Three testing sessions were defined as baseline, month 6 and month 12, according to two-time series: summer period, from May to October, and winter period from November to April. During these periods the median air temperatures registered in Portugal were 20.5 °C for summer, and 11.3 °C for winter. Rainfall values were 11.3 and 115.1 mm respectively for summer and winter periods. All participants were tested in the same daily period, from 10.00 to 12.00 h.

2.1. Sample

371 volunteers with 70 years old and over were recruited from Alto-Minho, Portugal aged population (74.1% female; aged 78.4 ± 5.3 years; height, 1.54 ± 0.09 m; weight, 70.2 ± 12.9 kg; BMI, 29.4 ± 4.5, at baseline). The sample size was determined by a priori estimation based on the effect size of 0.8, power of 0.95 and alpha level of 05, using the G” Power 3 program (version 3.0.3; Dusseldorf, Germany; Faul, Erdfelder, Lang, & Buchner, 2007), in an attempt to minimize type I and type II errors. The inclusion criteria of recruitment was presently healthy as screened by a family physician. The exclusion criteria were (a) lack of independent ambulation, (b) recent lower limb injuries, (c) neurologic or lower extremity orthopedic diagnoses, (d) corrected visual acuity worse than 20/100 or presence of a field defect, (e) acute illness.

Four groups were defined according to participants exercising practice level (see Fig. 1), named physical activity level (PA): Exercise Group (EG) exercised at least two times a week (n = 125); non Exercise Group (nEG) does not exercise or exercises less than two times a week (n = 141); Summer Group (SG) exercises at least two times a week in summer season but does not exercise or exercises less than two times a week in winter season (n = 57); Winter Group (WG) exercises at least two times a week in winter season but does not exercise or exercises less than two times a week in summer season (n = 48). Exercising type and intensity was not controlled by research. To participants were asked about exercising vs not exercising, number of sessions by week and period of year exercising. According to inquiry, participants were allocated to the groups. Informed consent was obtained from all participants and approval for the experimental procedures was obtained from the Scientific Council of Polytechnic Institute of Viana do Castelo.

2.2. Testing

Anthropometric variables body weight was measured to the nearest 0.1 kg, and height to the nearest 0.1 cm, using standard scales and stadiometer (Seca 217, Germany) with subjects wearing light clothing and no shoes. Body mass index (BMI) was calculated as the weight in kilograms divided by the height in meters squared.

Upper limbs muscle strength was assessed with the Handgrip Test (HG) on the right hand using a dynamometer (SH5001, SAEHAN Corporation, South Korea). For each measurement, patients were asked to perform their maximum voluntary contraction for 5 s. Each measurement was repeated three times with patients resting for 30 s between trials. The best performance was recorded for further analysis.

Lower limb muscle strength was assessed with the Isometric Knee Extension Test (KNEE), performed three times on the right leg with participants seated on a custom-built chair with a load cell (Vetek VZ101BS, Vaddo, Sweden). Each trial, participants were asked to perform their maximum voluntary contraction for 5 s. The test was repeated 3 times and participants rested for 2 min between trials. The best performance from the three trials was considered for further analysis.

Cardiorespiratory fitness was assessed with the Six Minutes Walking Test (6MW), performed according to the American Thoracic Society (American Thoracic Society, 2002) and the results expressed as the number of meters covered.

2.3. Statistical analysis

Descriptive statistical analysis, including mean and standard deviation, was calculated for both upper and lower limb muscle strength, and cardiorespiratory fitness, by group (EG, nEG, SG, and WG) and TIME (baseline, 6 months, 12 months).

A Repeated measures ANOVA with two between-subjects factors (PA and SEX) was run for each dependent variable (KNEE, HG, 6MIN), considering three TIME points (baseline, + 6 months, + 12 months). Mauchly’s test was used to examine the assumption of sphericity for each analysis and whenever the estimates of sphericity ($\epsilon < .50$) were violated, degrees of freedom were corrected using the adequate method.

The α level was set at $p \le 0.05$ for statistical significance. All statistical methods were performed using SPSS for Windows (ver. 22, SPSS Inc, Chicago, IL, 2013).

3. Results

The physical characteristics of the participants recruited in the present study by group, at baseline, are presented in Table 1.

No significant differences were found between groups in participants’ physical characteristics.

The results of the within-subjects analysis (Table 2) showed in a main effect of TIME on Isometric Knee Extension, Handgrip, and 6 Min Walking (all $p < .004$); and no interaction between TIME x SEX (all $p > .05$), or TIME x PA (all $p > .05$), or between TIME x SEX x PA (all $p > .05$). A significant general effect for SEX and PA was also found on the between-subjects (groups) analysis (all p’s < .001), and no

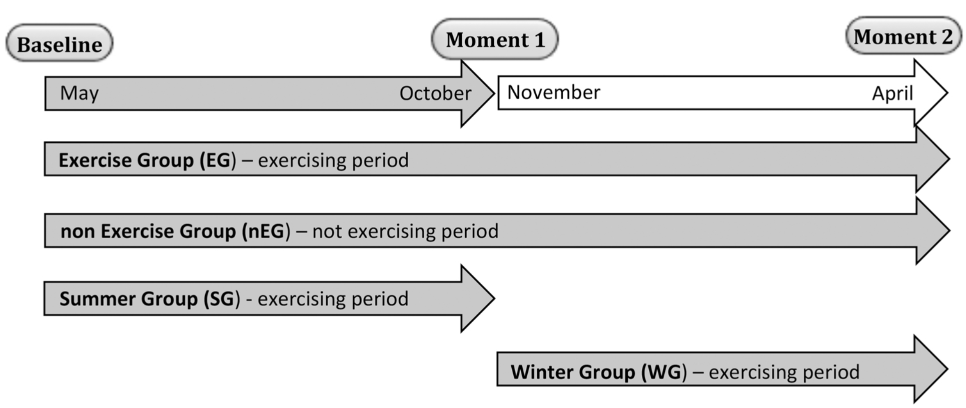

Fig. 1. Representation of assessment moments and groups’ training period.

Table 1
Physical characteristics of the subjects (means ± standard deviation) by group, at baseline.

Group	N	Age (Yrs)	Height (cm)	Weight (Kg)	BMI (Kg/m2)
EG	125 (73% F)	77.4 ± 5.9	155.0 ± 9.0	69.6 ± 11.8	29.0 ± 4.3
nEG	141 (78% F)	78.7 ± 4.2	153.0 ± 9.0	70.4 ± 13.7	29.9 ± 4.7
WG	48 (70% F)	79.1 ± 5.2	154.0 ± 8.0	69.4 ± 12.5	29.1 ± 4.2
SG	57 (67% F)	78.9 ± 5.3	156.0 ± 9.0	72.1 ± 13.8	29.6 ± 5.0

Note: F – female; EG exercises all testing time, at least two times a week; nEG does not exercise or exercises less than two times a week during all the testing time; WG exercise at least two times a week in winter season but not in summer season; SG exercises at least two times a week in summer season but not in winter season.

Table 2
The main effect of time, sex and physical activity level (PA) on Isometric Knee Extension, Handgrip, and 6 min Walking.

	Type III Sum of Squares	df	Mean Square	F	Sig.
Isometric Knee Extension					
Within-subjects					
TIME	292,68	2	146,34	8,01	,000
TIME*PA	11,96	6	1,99	0,11	,995
TIME*SEX	108,29	2	54,15	2,97	,052
TIME*PA*SEX	102,19	6	17,03	0,93	,471
Error(TIME)	12928,78	708	18,26		
Between-groups					
PA	10707,28	3	3569,09	10,92	,000
SEX	51840,97	1	51840,97	158,67	,000
PA*SEX	1047,23	3	349,08	1,07	,362
Error	115658,26	354	326,72		
Handgrip					
Within-subjects					
TIME	51,81	1,96	26,38	5,80	,003
TIME*PA	7,30	5,89	1,24	0,27	,948
TIME*SEX	16,89	1,96	8,60	1,89	,153
TIME*PA*SEX	10,76	5,89	1,83	0,40	,876
Error(TIME)	3217,86	706,98	4,55		
Between-groups					
PA	1718,59	3	572,86	5,64	,001
SEX	22154,37	1	22154,37	218,22	,000
PA*SEX	96,12	3	32,04	0,32	,814
Error	36548,62	360	101,52		
6 min Walking					
Within-subjects					
TIME	159613,889	2000	79806,94	45,28	,000
TIME*PA	12200,888	6000	2033,48	1,15	,330
TIME*SEX	1628,982	2000	814,49	0,46	,630
TIME*PA*SEX	5700,952	6000	950,16	0,54	,779
Error(TIME)	1117416,994	634,000	1762,49		
Between-groups					
PA	10707,278	3	3569,093	10,924	,000
SEX	51840,966	1	51840,966	158,672	,000
PA*SEX	1047,232	3	349,077	1068	,362
Error	115658,259	354	326,718		

interaction between SEX and PA for any of the variables tested.

For all three variables the performance has generally diminished over time as expected with this population (see Fig. 2), but differences between PA groups, and between sex groups was found (see between-subjects factor analysis in Table 2). Furthermore, tests of within-subjects contrasts showed a main quadratic trend of the Handgrip change over time [F(1,360) = 12.25; p = .001], and of the 6 Min Walking [F(1,317) = 14.65; p = .000]. The trend detected for the Knee Extension Strength was linear [F(1,354) = 1.07; p = .320].

Since no interaction effect was found on either the within- or the between-subjects analysis, we used LSD Post-Hoc tests to analyze the difference between each factor group (PA and SEX) (see Fig. 3).

Since no interaction effect was found on either the within- or the between-subjects analysis (see Table 2) we can interpret that the trajectories of the different groups (PA and SEX) were similar over time, and analyze the main differences between them using post-hoc tests. As a result, and for all three variables, we found that: (1) men were always fitter than women ($p < .001$); (2) the EG group showed better results than all the others ($p < .004$), (3) the nEG group had always worse performance than all others ($p < .02$); (4) SG and WG groups showed similar results ($p = .41$).

4. Discussion

The aim of this study was to determine the effects of summer and winter environmental conditions on physical fitness, in both exercise and non-exercise aged population. We found that the longitudinal pattern of physical fitness across the year was similar, independent of the elderly exercising all year around, not exercising at all, or having a seasonal mode of exercising (only winter, or only summer). The effect of exercise was clear, with the EG group showing to be significantly better fit, and the nEG group being significantly less fit than all other groups. So, a hypothetical effect of seasonality in physical fitness should had been noted in the differences between the longitudinal pattern of changes of the nEG, and the summer and winter exercising groups. The SG pattern should had been different from the nEG particularly for the summer period; and the WG for the winter period. Since that did not happened we may conclude for the lack of seasonality effect on physical fitness of aged populations.

It is a fact that previous studies have reported variations on physical activity according to the annual season, being generically higher during the summer and lower during the winter (Bento, Romero, Leitão, & Mota, 2014; Clemes et al., 2011; Hagstromer, Rizzo, & Sjostrom, 2014; Lloyd & Miller, 2013; Tucker & Gilliland, 2007), and having an impact on body weight (Hagstromer et al., 2014; Lloyd & Miller, 2013) even if, when specifically investigated, weather conditions only showed a modest effect on the individual variation of PA (Badland, Christian, Giles-Corti, & Knuiman, 2011). The relationship between this expected seasonality effect of PA on physical fitness in the elderly has not been yet established in the literature. In fact, and to our knowledge, this is the first study to address the issue of physical fitness variation of aged

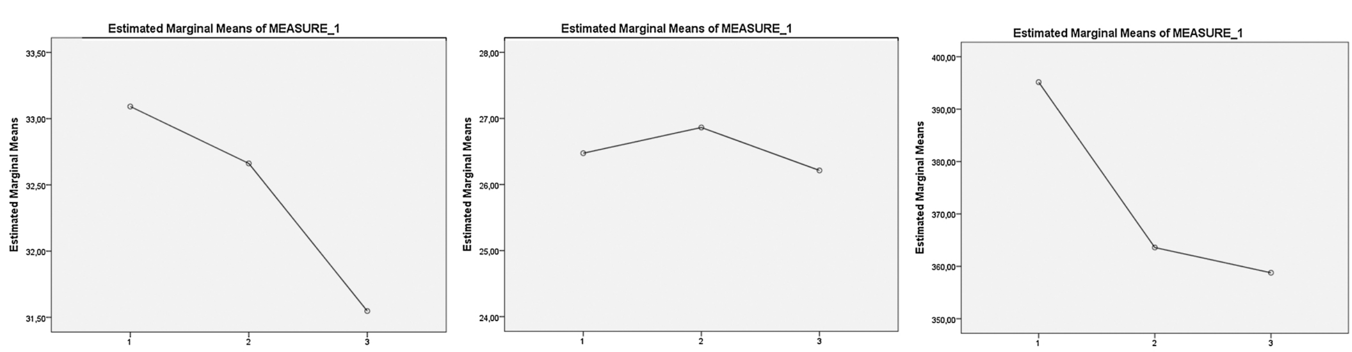

Fig. 2. Representation of main general performance on Isometric Knee Extension Test, Handgrip Test, and 6 min Walking Test, over time.

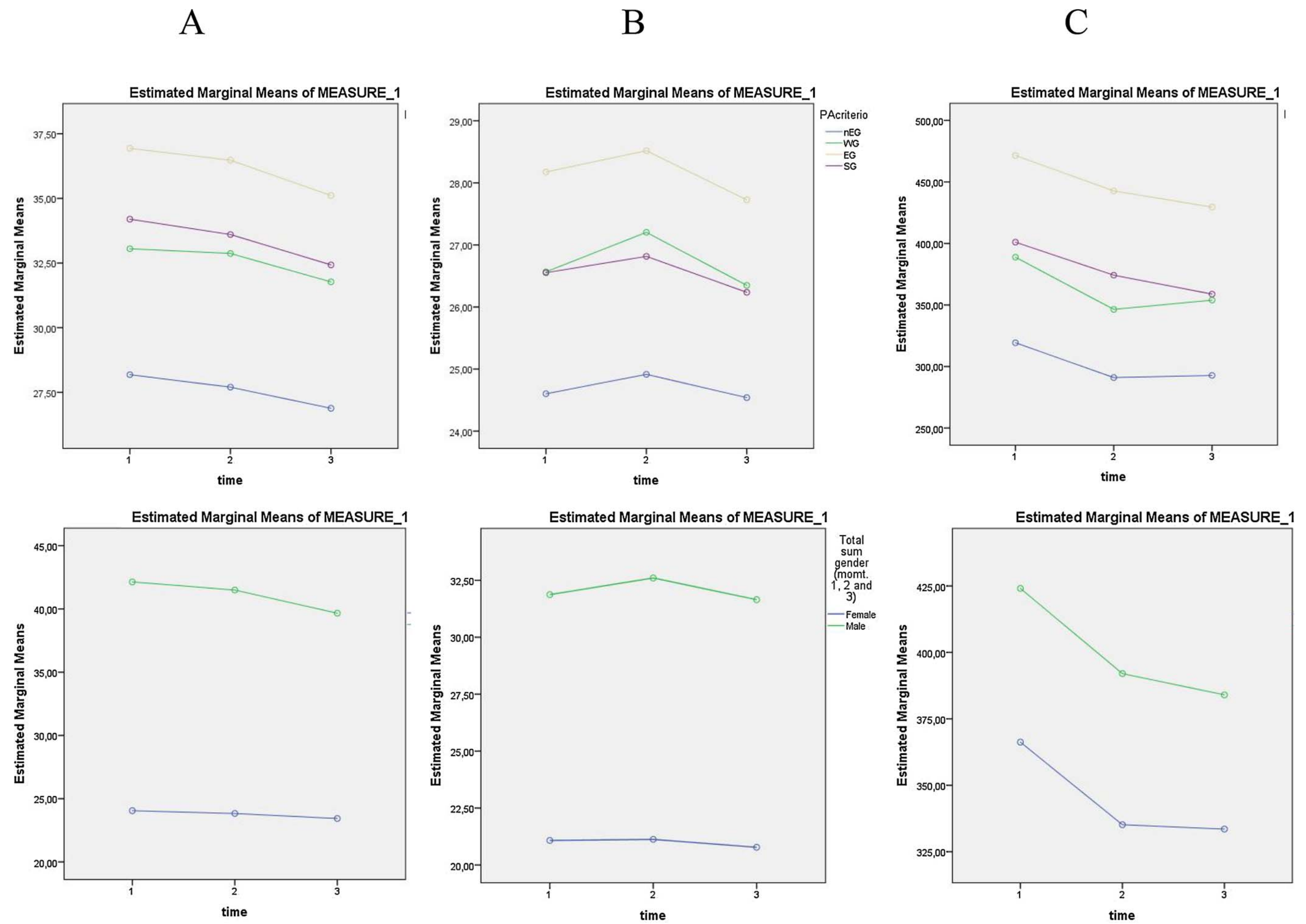

Fig. 3. Representation of PHYSICAL ACTIVITY groups and SEX groups' performance on Isometric Knee Extension Test (A), Handgrip Test (B), and 6 min Walking Test (C), over time.

population depending on seasonality effects.

Physical fitness changes in aged people are well documented in the literature. For example, Vandervoort (2002) reported lose in muscle strength of 1–2% per year and Schrack, Simonsick, Chaves, and Ferrucci (2012) found an decrease in gait speed after age 65. The present findings support such evidences, as all groups, independent of the exercise condition, showed to decline from moment 1 to moment 3, one year later.

Our results are also in accordance with the literature when it shows that regular exercise improves physical fitness (Bouaziz, Schmitt, Kaltenbach, Geny, & Vogel, 2015; Mendonca et al., 2016), as all exercise groups (EG, WG, SG) showed significantly better fitness scores than nEG across all three moments. In addition we saw that the physical fitness benefit from exercising all the time (EG) was also significantly higher than when exercising just during a season (WG, SG), allowing us to conclude for a clear dose-response effect of exercise in old aged populations.

The sex-related differences in physical fitness have been deeply reported (Milanović et al., 2013; Shephard, 2001) and are corroborated by the present study. However, little was known about the pattern and the sex-related changes of physical fitness of aged populations across a year span. The current findings show that both male and female had a similar pattern of decline on physical fitness, showing that the age-related physical fitness decline is not sex dependent.

5. Conclusion

The present research aimed to investigate the effects of summer and winter environmental conditions on physical fitness, in both exercise and non-exercise aged population. The major findings were that seasonal exercising may not have impact on physical fitness, in male or female. Groups exercising in summer or winter time showed similar physical fitness across year span.

Despite being stronger and fitter, aged individuals who exercise throughout the year or exercise seasonally showed a similar pattern of decline in physical fitness to their counterparts who do not exercise.

In the same line of evidences, male is stronger and fitter than female but the pattern of changes in physical fitness are similar.

These findings provide insight for understanding the factors that underlie physical fitness variation on aged people, across year span.

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