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Effects of plank exercise on respiratory capacity, physical fitness, and immunocytes in older adults

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Plank is a readily accessible form of exercise that can benefit individuals of various fitness levels. However, its effectiveness in older individuals has not been conclusively established. Specifically, its impact on respiratory function, physical fitness, and immunocytes in them has not been thoroughly verified. The study encompassed participants with an average age of 64.33±1.98 years. All participants were randomly assigned to either the control group (COG) or the plank exercise group (PXG). The plank exercise was conducted 3 days a week for 12 weeks. While the values in the COG deteriorated, the PXG showed significant improvements in several parameters. Forced expiratory volume in one second and peak expiratory flow increased by approximately 27% and 16%, respectively, in the PXG, demonstrating significant differences ($P<0.001$) between the two groups. Additionally, VO_{2max}, grip strength, and sit-ups increased by about 12%, 18%, and 42% in the PXG. Notably, innate immunocytes, such as NK cells, increased by approximately 30% in the PXG. For adaptive immunocytes, including CD3+ T cells, CD4+ T cells, and CD8+ T cells, there were notable increases of around 18%, 19%, and 28%, respectively, in the PXG. These findings underline significant differences ($P<0.001$) between the two groups. This study provides confirmation that engaging in plank exercise can enhance the function of immunocytes, while also improving respiratory capacity and physical fitness in older adults.

Keywords: Plank exercise, Respiratory capacity, Immunocyte, Older people, Physical fitness

INTRODUCTION

In recent times, the world has experienced a significant number of casualties as a result of the coronavirus, which can lead to respiratory system infections in both humans and animals (Zhang et al., 2020). While hygiene and vaccines play a crucial role in preventing this virus, it's also widely recognized that building a robust immune defense system through regular exercise is of great importance (Walsh, 2018).

The plank exercise, originating from pilates, yoga, and stretching, can be done with minimal space requirements and is accessible to virtually anyone. This exercise, which engages the entire body, has the potential to burn a significant amount of calories and build muscle in a relatively short time (Park and Park, 2019). Research indicates that plank exercises are effective for improving strength and endurance (Akuthota et al., 2008; Behm et al., 2010), reducing lower back pain (Kline et al., 2013), and preventing falls (Granacher et al., 2013a). Previous studies have also demonstrated the effectiveness of plank exercises in activating core muscles, but their effects on the body's immune cells are still not well known. In addition to the benefits mentioned earlier, plank exercise is a popular choice for many individuals due to its ability to enhance the core muscles in the abdominal and lower back regions, as demonstrated by Byrne et al. (2014). Furthermore, it demands minimal time, space, and expense, making it an attractive option for fitness enthusiasts. The plank exercise involves maintaining a position where the body is supported by the forearms and both feet in a straight line, as described by Calatayud et al. (2017). This exercise is particularly effective in enhancing overall body stability and mobility by focusing on strengthening the abdominal muscles

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within the core muscle groups.

Up to this point, the plank exercise has been recognized as a convenient at-home workout that targets core muscles. However, its impact on respiratory function and its potential positive effects on immune cells related to respiratory infections, such as those caused by the coronavirus, have not been well understood. Additionally, it remains unclear whether plank exercises are suitable for older individuals or if they bring about changes in respiratory function and immune cell activity. Hence, the primary objective of this study was to examine alterations in respiratory capacity, physical fitness, and immune cell function in older adults.

MATERIALS AND METHODS

Participants

The study involved male and female older adults with ages ranging from 60 to 69, and the mean age was 64.33±1.98 years. In this study, participants were recruited from elderly individuals residing in a Seoul Seniors Tower in Korea. These individuals were not engaged in regular exercise, and this was verified by assessing their daily activities and calorie intake. Participants were exclusively recruited from older individuals who demonstrated the ability to independently carry out daily activities and were in good physical health for engaging in physical activities. Their selection criteria also included having no prior experience with plank exercises. Additionally, all participants were non-smokers, free from back pain, and did not consume alcohol. Individuals who had undergone specific medical treatments or were taking medications that could affect their physical or psychological conditions, or had undergone significant surgery within the year prior to the study, were excluded from participation. The sample size for the study was determined using the GPower software (version 3.1.9.7, Heinrich-Heine-Universität, Düsseldorf, Germany). The calculations considered various parameters, including an effect size of f^2 (V)=0.25, an alpha error probability of 0.05, a power of 0.95, the existence of two groups, and a numerator difference of two (pre- and postvalues). According to GPower's calculations, the ideal sample size for the experimental design was found to be 54 participants. To account for potential dropouts, the study selected 60 participants. They were assigned unique identification numbers and then randomly allocated to one of two groups using random number tables. To ensure a genuinely random allocation, the Research Randomizer program (Urbaniak and Plous, 2023) was used. Each participant drew a numbered ticket from a container, and these individual sets were input into the program to assign them randomly to either the control group (COG) or the plank exercise group (PXG), each consisting of 30 participants as shown in Table 1. More precisely, there were no dropouts among the participants from the initial enrollment to the analysis phase.

Table 1. Physical characteristics of the participants

Variable	COG (n=30)	PXG (n=30)	*Z*	*P*-value	η^2
Age (yr)	64.40±2.08	64.27±1.91	-0.352	0.725	0.001
Gender	1.40±0.50	1.40±0.50	0.000	1.000	0.000
Height (cm)	167.25±9.55	169.70±6.50	-0.621	0.535	0.023
Weight (kg)	65.96±9.91	66.66±10.18	-0.399	0.690	0.001
Muscle mass (kg)	25.41±4.75	25.60±4.48	-0.096	0.923	0.000
Fat mass (kg)	16.20±3.35	16.33±3.82	-0.163	0.871	0.000
Percent fat (%)	25.03±6.10	24.65±5.12	-0.340	0.734	0.001

Valeus are presented mean±standard deviaiton.
COG, control group; PXG, plank exercise group.

Experimental design

This was a prospective cross-sectional study conducted to investigate the impact of plank exercises on respiratory capacity, physical fitness, and immunocytes in older adults. All data for this study were collected between March 13, 2023 and June 16, 2023. After obtaining approval from the Institutional Review Board under the reference HS22-05-03, which was granted by the Health Science Human Studies Committee of Hanseo University, the experiment was carried out. Detailed explanations of all study procedures were provided to the participants, and efforts were made to minimize external influences by recording and evaluating the dietary intake (Korean Nutrition Society, 2023) and physical activity (Cheng, 2016) of all participants in both groups on a daily basis. The plank exercise program for the PXG was conducted 3 days a week (on Mondays, Wednesdays, and Fridays) for a duration of 12 weeks.

Respiratory capacity measures

Respiratory function assessment involved the use of a spirometer manufactured by Switzerland. The following parameters were measured: Forced expiratory volume in 1 sec (FEV_1) and peak expiratory flow (PEF). To conduct the tests, participants blocked their noses with a stopper and inserted a disposable mouthpiece into their mouths. They then exhaled their maximum breath to measure the above variables after taking a deep inhalation. Before the actual testing, participants underwent practice sessions to become familiar with the spirometry measurement technique. Each subject underwent the spirometry test 3 times, and the highest recorded value among the three attempts was used for statistical analysis, following the approach detailed in Sutbeyaz et al. (2010). Additionally, this research assessed the resting respiratory rate (rRR) of each participant for a duration of 60 sec. Participants were instructed to close their eyes and breathe comfortably. One researcher determined respiratory rate by observing the participants' natural chest movements and counting their breathing while they were relaxed.

Physical fitness measures

This study assessed various aspects of health-related physical fitness, including body composition, strength, muscle endurance, and cardiopulmonary endurance using a graded exercise test (GXT). Body composition was measured using a bioelectrical impedance analysis method with a body composition analyzer (Inbody 770, Biospace, Seoul, Korea) to obtain participants' demographic characteristics. Strength was assessed through a grip strength test, performed with a Smedley dynamometer (Takei Inc., Tokyo, Japan). The participants held the dynamometer without touching any other part of their body. After measuring both hands alternately twice, the maximum value was recorded, and the mean value from both hands was used. Muscle endurance was measured using a sit-up test lasting for 1 min. The total number of completed sit-ups was recorded. Participants lay down with their backs on the floor, bent their knees at right angles, secured their feet on the sit-up board, and interlocked their fingers behind their head. This study evaluated the maximal oxygen uptake (VO_{2max}) as an indicator of cardiopulmonary endurance by conducting a GXT. Various devices were utilized for this assessment, including an electrocardiogram (Q-4500, SunTech Medical Inc., Morrisville, NA, USA), an automatic sphygmomanometer (M-412, SunTech Medical Inc.), a gas tester (QMC4200, SunTech Medical Inc.), and a treadmill (Q65 Series 90, Quinton Instrument Co., Seattle, WA, USA). The test followed the modified Bruce protocol, which required participants to walk or run until they reached their maximal rating of perceived exertion (RPE), signifying an all-out effort level. This approach helped determine their VO_{2max} and provided insights into their cardiopulmonary endurance.

Immunocyte measures

Blood samples were collected in the morning from participants who had fasted for approximately 10 hr. This research aimed to examine changes in complete blood counts as well as lymphocyte and granulocyte subsets. The analysis involved determining the percentage and absolute cell counts of peripheral blood cell subsets using the following procedure: A 50-μL blood sample was treated with anti-human antibodies (anti-CD3, anti-CD4, anti-CD8, and anti-CD56) obtained from BD Biosciences (Franklin Lakes, NJ, USA). After a 15-min incubation in the dark at room temperature, red blood cells were broken down by adding 450 μL of Fluorescence-Activated Cell Sorting (FACS) lysing solution to each test tube, followed by another 15-min incubation in the dark at room temperature. Subsequently, these samples were analyzed using the FACS Canto II system from BD Bioscience, and the results, presented as percentages, were processed with Flowjo software (Treestar, Ashland, OR, USA).

Plank exercise program

Before and after the plank exercises, participants engaged in 5-min sessions of lying stretches. Throughout the workout phase, participants were required to maintain a straight and stable alignment from their head to their toes, ensuring that their hips did not sag, while keeping their shoulders and elbows flexed at a 90° angle. The plank exercise involves determining the maximal RPE and, based on this RPE, performing the exercise at different intensities: 60% intensity during the first 1 to 4 weeks, 70% intensity from weeks 5 to 8, and 80% intensity from weeks 9 to 12. While plank exercise is effective for strengthening various muscle groups, including the abdominals, back, shoulders, arms, and lower body (Tong et al., 2014), it's important to avoid excessive or improper execution as it can lead to joint problems. In particular, it may strain the wrists, elbows, shoulders, and spinal joints. Therefore, participants were instructed to discontinue the plank exercise if they experienced any discomfort or pain in these areas during the process of determining their maximal RPE using the Borg category ratio-10 scale, which rates intensity on a scale from 1 to 10 (Guo et al., 2017). This scale typically ranges from 0 (representing complete rest) to 10 (representing the most strenuous effort). During the initial 1 to 4 weeks, the objective of the plank exercise was to achieve a duration of 20 min, with each individual performing sets at 60% of their maximal RPE. To meet this target, participants completed approximately 15–16 sets of plank exercises during this period. In the subsequent 5 to 8 weeks, the goal was to extend the duration to 25 min, and in the final 9 to 12 weeks, the aim was to reach 30 min as shown in Table 2. After completing each set of plank exercises, participants were instructed to take a 1-min break.

Statistical analysis

Statistical analysis for this study was conducted using IBM SPSS Statistics version 25.0 (IBM Corp., Armonk, NY, USA). The nor-

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Table 2. Plank exercise program for older adults

Items	Measures/performances	Time/set
max RPE	Time to reach max RPE (sec)	136.30±24.70
Weeks 1–4	Time equivalent to 60% of max RPE (sec)	82.40±14.35
	Set that reached the goal of 20 min	15.33±2.35
	Time to reach set (sec)	1,231.60±22.10
Weeks 5–8	Time equivalent to 70% of max RPE (sec)	95.41±17.29
	Set that reached the goal of 25 min	15.53±2.54
	Time to reach set (sec)	1,440.72±25.53
Weeks 9–12	Time equivalent to 80% of max RPE (sec)	109.04±19.76
	Set that reached the goal of 30 min	15.53±2.54
	Time to reach set (sec)	1,646.53±29.18

Valeus are presented mean±standard deviaiton.
max RPE, maximal ratings of perceived exertion.

Table 3. Changes and differences of respiratory capacity

Variable	COG	PXG	*Z*	*P*-value	η^2
FEV_1 (L)					
Pre	1.93±0.44	1.94±0.44	-0.178	0.859	0.000
Post	1.59±0.35	2.41±0.59	-5.575	0.000	0.424
Δ%	-15.45±16.85	27.07±29.99	-5.869	0.000	0.442
PEF (L/sec)					
Pre	3.51±0.64	3.50±0.67	-0.022	0.982	0.000
Post	2.82±0.60	3.99±0.71	-5.236	0.000	0.449
Δ%	-17.74±18.83	15.82±18.61	-5.464	0.000	0.454
rRR (reps)					
Pre	18.23±2.64	18.47±2.75	-0.757	0.449	0.002
Post	19.30±2.22	15.43±3.76	-3.726	0.000	0.289
Δ%	7.05±13.81	-14.63±24.26	-3.808	0.000	0.238

Valeus are presented mean±standard deviaiton.
COG, control group; PXG, plank exercise group; FEV_1, forced expiratory volume in 1 sec; PEF, peak expiratory flow; rRR, resting respiratory rate.

mality of all measured variables was assessed with the Shapiro–Wilk normality test. To compare continuous outcomes between groups, the non-parametric Mann–Whitney *U*-test was employed. In this study, delta % was calculated for each period to enable detailed data analysis, and the significance of this value was also tested using the Mann–Whitney *U*-test. The effect size (η^2) was calculated based on Cohen *d*, which is derived from the mean difference of the groups divided by the pooled standard deviation, following the framework outlined by Cohen (1992). Cohen *d* effect sizes are typically classified as small (0.2–0.3), medium (~0.5), or large (≥0.8). For all analyses, the significance level was set at $P \leq 0.05$.

RESULTS

Demographic and physical characteristics before the experiment

In the COG, there were 12 females, constituting 40.0% of the group, and 18 males. PXG also consisted of 12 women and 18 men, which matched the gender distribution of the COG. As shown in Table 1, there were no significant differences in terms of age, gender distribution, height, or body weight between the two groups. Furthermore, various other body composition factors, such as muscle mass, fat mass, and percentage of body fat, also did not display any statistically significant variations between the groups prior to the commencement of the study. Although not presented in the table, the mean daily dietary intake over the course of 12 weeks was determined to be 1,371.67±202.98 kcal for the COG and 1,323.13±208.16 kcal for the PXG. The comparison between the two groups demonstrated no statistically significant difference ($Z=-0.814$, $P=0.415$, $\eta^2=0.014$). Likewise, the daily physical activity levels were documented as 1,509.47±373.14 MET·min/wk for the COG and 1,532.10±477.48 MET·min/wk for the PXG. This data also showed no significant difference between the two groups ($Z=-0.096$, $P=0.923$, $\eta^2=0.001$).

Changes and differences of respiratory capacity

As indicated in Table 3, there were no notable differences in FEV_1, PEF, and rRR prior to the commencement of the experiment between the two groups. However, following the 12-week study, FEV_1 decreased by approximately 15% in the COG and increased by about 27% in the PXG. This observed contrast between the groups was statistically significant. Following the 12-week experiment, PEF exhibited a decrease of approximately 18% in the COG, whereas it increased by about 16% in the PXG, demonstrating a significant distinction between the groups. Furthermore, in the case of rRR, it increased by about 7% in the COG, while it decreased by about 15% in the PXG, again showing a significant difference between the two groups. It's noteworthy that these changes in FEV_1 ($\eta^2=0.442$), PEF ($\eta^2=0.454$), and rRR ($\eta^2=0.238$) were associated with large effect sizes (≥0.14).

Changes and differences of physical fitness

As depicted in Table 4, there were no significant disparities in VO_{2max}, grip strength, and sit-ups before the initiation of the experiment across the two groups. However, at the end of the 12-week study, VO_{2max} displayed a reduction of approximately 9% in the COG, while it increased by about 12% in the PXG, indicating a noteworthy distinction between the groups. Furthermore, grip strength decreased by roughly 12% in the COG, but it in-

Table 4. Changes and differences of physical fitness factors

Variable	COG	PXG	*Z*	*P*-value	η^2
VO_{2max} (mL/kg/min)					
Pre	30.13±5.58	29.46±7.24	-0.481	0.631	0.003
Post	26.66±4.81	32.20±5.81	-3.579	0.000	0.218
Δ%	-9.25±19.72	11.88±15.26	-3.888	0.000	0.271
Grip strength (kg)					
Pre	32.30±7.51	31.48±6.54	-0.688	0.492	0.003
Post	27.53±5.38	36.71±7.91	-4.407	0.000	0.323
Δ%	-12.14±19.25	17.68±17.54	-5.160	0.000	0.404
Sit-ups (reps)					
Pre	15.03±4.21	16.30±4.84	-0.890	0.373	0.020
Post	12.57±3.47	21.90±4.52	-5.892	0.000	0.581
Δ%	-13.58±19.95	41.86±37.42	-5.508	0.000	0.469

Valeus are presented mean±standard deviaiton.
COG, control group; PXG, plank exercise group; VO_{2max}, maximal oxygen consumption.

creased by about 18% in the PXG, revealing a significant difference between the groups. In the case of sit-ups, a measure of muscular endurance, it decreased by about 14% in the COG, while it surged by about 42% in the PXG, demonstrating a significant contrast between the two groups. It is important to note that these changes in VO_{2max} (η^2=0.271), grip strength (η^2=0.404), and sit-ups (η^2=0.469) were characterized by substantial effect sizes (≥0.14).

Changes and differences of immunocytes

As indicated in Table 5, prior to the commencement of the experiment, natural killer (NK) cells, CD3+ T cells, CD4+ T cells, and CD8+ T cells exhibited no significant distinctions between the two groups. However, at the end of the 12-week study, there were noteworthy changes. NK cells decreased by approximately 11% in the COG, while they increased by about 30% in the PXG, indicating a significant difference between the groups. CD3+ T cells decreased by around 15% in the COG, but they increased by about 18% in the PXG, displaying a significant distinction between the groups. In the case of CD4+ T cells, they decreased by roughly 15% in the COG, but increased by about 19% in the PXG, again revealing a significant difference between the groups. CD8+ T cells also exhibited a reduction of about 11% in the COG, while they increased by about 28% in the PXG, highlighting a significant difference between the two groups. It's important to emphasize that these changes in NK cells (η^2=0.316), CD3+ T cells (η^2=0.426), CD4+ T cells (η^2=0.267), and CD8+ T cells (η^2=0.312) were characterized by substantial effect sizes.

Table 5. Changes and differences of innate and adaptive immunocytes

Variable	COG	PXG	*Z*	*P*-value	η^2
WBC (×10^3/μL)					
Pre	5.81±0.70	5.77±0.71	-0.081	0.935	0.001
Post	5.67±0.99	5.96±0.62	-1.554	0.120	0.032
Δ%	-1.86±16.55	4.56±15.73	-1.353	0.176	0.039
NK cells (%)					
Pre	8.81±2.73	8.87±2.65	-0.104	0.918	0.000
Post	7.43±1.76	11.12±3.37	-4.724	0.000	0.327
Δ%	-10.78±24.00	29.78±35.56	-4.436	0.000	0.316
CD3+ T cells (%)					
Pre	59.07±9.09	58.63±10.05	-0.229	0.819	0.001
Post	49.52±9.51	68.11±11.39	-5.308	0.000	0.448
Δ%	-15.18±16.80	18.45±22.47	-5.277	0.000	0.426
CD4+ T cells (%)					
Pre	37.99±10.90	37.97±8.07	-0.274	0.784	0.000
Post	30.49±6.30	43.30±6.81	-5.445	0.000	0.497
Δ%	-14.59±23.39	18.84±32.22	-4.109	0.000	0.267
CD8+ T cells (%)					
Pre	18.56±5.30	18.85±2.93	-0.267	0.790	0.001
Post	15.68±3.18	23.62±5.40	-5.399	0.000	0.453
Δ%	-10.80±23.31	28.01±34.29	-4.399	0.000	0.312

Valeus are presented mean±standard deviaiton.
COG, control group; PXG, plank exercise group; WBC, white blood cell; NK, natural killer.

DISCUSSION

This study observed multiple alterations in respiratory capacity, physical fitness, and immunocyte function in older adults after 12 weeks of plank exercise. Regarding respiratory variables, the study noted that FEV_1 and PEF increased by approximately 27% and 16%, respectively, in the PXG. In the case of rRR, it increased by about 7% in the COG but decreased by roughly 15% in the PXG. Furthermore, this study demonstrated that plank exercise leads to an increase in maximum oxygen intake, as well as improvements in strength and muscular endurance. These improvements were associated with positive changes in immune cells.

Training the strength and endurance of the muscles in the trunk region is a crucial aspect of resistance training, and it has garnered increased attention in scientific literature and rehabilitation fields (Byrne et al., 2014). While the effectiveness of trunk muscle training as a tool for enhancing athletic performance may lack robust research support, positive outcomes have been documented in various areas. These include promoting low back health, reducing the risk of injuries, enhancing the ability to transfer power to the extremities, and preventing falls among senior individuals (Gra-

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nacher et al., 2013a; Granacher et al., 2013b). Granacher et al. (2013b) conducted research to show that core strength instability training, which is akin to plank exercises, is a viable form of exercise for older adults. They found that this type of training improved spinal mobility, dynamic balance, functional mobility, and trunk strength. Consequently, they proposed that this training program could serve as a supplementary or alternative approach to traditional balance and resistance training. In this study, the aim of the plank exercise for the initial 1 to 4 weeks was for each individual to reach a duration of 20 min while performing sets at an intensity level of 60% of their maximum RPE. The subsequent goal was to increase the duration to 25 min during weeks 5 to 8 and further extend it to 30 min in weeks 9 to 12. To attain this objective, older adults needed to complete approximately 15 to 16 sets of plank exercises. In summary, plank exercise is a viable option even for older individuals, and this form of exercise can lead to improvements not only in the development of physical strength, including core muscles but also in respiratory function and immune cell function, as observed in this study.

In particular, when examining the results of this study and comparing them to the pre-experimental values, it becomes evident that in the COG, FEV_1 and PEF experienced reductions of approximately 15% and 18%, respectively, while in the PXG, they increased by about 27% and 16%. Conversely, rRR increased by around 7% in COG but decreased by about 15% in PXG, indicating an improvement in respiratory function. Concerning physical fitness components, VO_{2max} and grip strength declined by roughly 9% and 12%, respectively, in COG, whereas they increased by about 12% and 18% in PXG. To be more specific, sit-ups, which assess the endurance of trunk muscles, decreased by around 14% in COG but surged by about 42% in PXG, underscoring the substantial impact of plank exercise on core muscles. These results indicate that the duration of plank exercise per set for the older participants in this study was appropriate, aligning with previous research (Byrne et al., 2014; Granacher et al., 2013a; Granacher et al., 2013b). In essence, this implies that enhancing core muscles through plank exercises may play a role in enhancing respiratory function.

Furthermore, this study verified that, in addition to the changes in respiratory function and physical strength factors, immune cell function improved after engaging in the aforementioned plank exercise. In particular, NK cells, a type of innate immune cell observed in this study, decreased by around 11% in the COG, which did not engage in plank exercise. In contrast, they increased by approximately 30% in the PXG, indicating a significant difference between the two groups. Notably, for adaptive immune cells, including CD3+ T cells, CD4+ T cells, and CD8+ T cells, there were declines of approximately 15%, 15%, and 11% in COG, while they increased by about 18%, 19%, and 28% in PXG, underscoring significant distinctions between the two groups. These results can be interpreted as the plank exercise having a positive impact on the immune cell function of the elderly participants. Specifically, the enhanced function of innate and/or adaptive immunocytes suggests that plank exercise may provide protection against external substances (i.e., virus or bacteria). In light of the lasting effects of the recent coronavirus disease 2019 (COVID-19) pandemic, many elderly individuals have faced disruptions in their lives and health, experiencing significant changes in their respiratory and immune function. To counteract these challenges, the continuous practice of plank exercise is recommended to the older people. T cells, including both CD4+ and CD8+ T cells, play a crucial role in the body's defense against viruses by facilitating the production of pathogen-specific antibodies, stimulating T-dependent B cells, and eliminating virus-infected cells (Maloir et al., 2018). The significance of CD4+ T cells in controlling the replication of the severe acute respiratory syndrome coronavirus and mitigating disease severity has been underscored through studies involving T cell-deficient mice, highlighting the pivotal role of CD4+ T cells in primary severe acute respiratory syndrome coronavirus infection (Maloir et al., 2018). Virus-specific CD4+ T cells are essential for complete virus clearance, while memory CD8+ T cells also contribute significantly through the production of various cytokines and cytolytic molecules like granzyme B (Chen et al., 2010). In the context of the COVID-19 pandemic, as we have all witnessed, there was a substantial reduction in the total number of T cells, encompassing both CD4+ and CD8+ T cells (Diao et al., 2020; Hosseini et al., 2020). Paradoxically, these findings suggest that the plank exercise observed in this study may have helped alleviate or prevent some of the adverse effects caused by the coronavirus.

This study has verified that plank exercises, performed at varying levels of intensity from light to high, enhanced immunocyte function and various physical fitness components, including respiratory capacity, in older adults. Nevertheless, it is important to acknowledge the limitations of our study. Firstly, the sample size was relatively small. Secondly, while there are numerous types of immunocytes, this study focused on a specific subset of immune cells. Given these limitations, further research that explores the effectiveness of plank exercises on a larger and more diverse participant pool, encompassing a broader range of immunocyte assessments, is encouraged.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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