Can Training trunk musculature influence musculoskeletal pain and physical performance in military police officers?

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Can training trunk musculature influence musculoskeletal pain and physical performance in Military Police Officers?

To investigate the effect of a Trunk Training (TT) program on the general musculoskeletal pain (GMP) and physical performance of Military Police Officers. Twenty officers were divided into either control group (CG) or TT group (TTG). Both groups performed nine weeks of traditional physical training. However, the TTG had 25-minutes allocated to TT during each scheduled physical training period. Anthropometric, trunk endurance, and physical fitness tests were completed pre- and post-training for both groups. Both groups also answered a weekly questionnaire about their GMP. Post-training, trunk endurance performance was significantly higher (p<0.05) and the GMP significantly lower (p<0.05) in the TTG when compared to the CG. Improvement in side plank test scores was associated with a decreased in GMP (r= -0.495, p<0.05). TT can reduce the perception of GMP in addition to increasing the endurance of the trunk muscles. The side plank was the only physical test associated with GMP.

**Keywords:** Low back pain, Isometric exercises, Tactical athlete, Physical fitness, Core muscle.

**Practitioner Summary**

Trunk Training can reduce general musculoskeletal pain and increase the endurance of the trunk muscles without a concomitant loss in general fitness in elite Military Police Officers. This research lasted 11 weeks and presents real-world and pragmatic findings.
Introduction

Musculoskeletal conditions affect 13% to 47% of the general population and are considered to have a major impact on quality of life (Cimmino et al., 2011; Larsen et al., 2018). In 2011, musculoskeletal conditions costs were estimated to be in the order of $213 billion in the United States, highlighting the fiscal costs of these conditions (World Health Organization, 2019). Noting these life impacts and costs, musculoskeletal injuries, and subsequent conditions, have been attributed to various tactical occupations, notably those associated with physical and psychological demands (Cimmino et al., 2011). Between the different professions, there is a consensus that tactical occupations, which include firefighters, law enforcement, and military personnel, are known to suffer from a high prevalence of musculoskeletal injuries (Lyons et al., 2017; McDonald et al., 2016; Robinson et al., 2019).

Military Police Officers (MPO) are subjected to long work shifts, working in confined spaces with sustained postures, are exposed to high volumes of vehicle vibrations, and are required to wear and carry heavy loads imparted by their personal protective equipment (Gruevski et al., 2016; Holmes et al., 2013; Ramstrand et al., 2016). Specific tasks performed by MPOs can include, but are not limited to, interjecting in civil conflicts and rebellion containment, all performed whilst wearing (e.g., bulletproof vests, ballistic helmets) and carrying (e.g., shields, weapons) protective and operational equipment that can exceed 20 kg (Carlton et al., 2014; Orr et al., 2020). As such, MPOs are subjected to high physical demands and psychological challenges during their working hours (Larsen et al., 2018; Ramstrand et al., 2016). Given these physical requirements, a concern noted by Pryor et al. (2012) is the finding that 50% of Special Weapons and Tactics (SWAT) operators failed to successfully complete a lower back endurance test (60 seconds), indicating weak lower back musculature. Given their occupational load carriage need, lack of trunk
strength may predispose MPOs to an increased risk of sustaining injury to the back (Pryor et al., 2012).

One factor that may impact on the prevalence of musculoskeletal pain symptoms is inadequate physical fitness (Knapik et al., 2011; McDonald et al., 2016). Reduced trunk stability, for example, has been shown to be related to an increased risk of injury and the onset of musculoskeletal pain (Hibbs et al., 2008). Stability is derived from the ability of the muscles to generate force (i.e., strength) and to sustain postures or activities (i.e., endurance) using a timely recruitment of a set of muscles (i.e., control) (Hibbs et al., 2008). Thus, trunk stability presents as the ability to control the position of the trunk during dynamic loading and movement conditions (Hibbs et al., 2008). It has been proposed that if the trunk muscles are conditioned they will offer good postural control or stability, increase movement performance and reduce the risk of injury (Conway et al., 2016; Kibler et al., 2006; Mooney et al., 1997).

MPOs are generally considered to be physically fit as they are typically complete intense physical training programs and are subjected to regular fitness tests (Robinson et al., 2019). Paradoxically, MPOs present with a high prevalence of musculoskeletal pain (Larsen et al., 2018; McGill et al., 2015). This paradox is not uncommon given that physical training designed to increase fitness is often a leading source of injuries in tactical populations (McDonald et al., 2016). That does not mean that physical training exposure and fitness are synonymous. Childs et al. (2010) showed that soldiers engaged in a 12-week traditional training program (including traditional sit-up exercises) had more days of work restriction related to low back injury (~ 8.3 vs. 4.2 days) than their peers who performed specific trunk training with isometric exercises that were not in the soldiers' typical training in the soldiers' training routine. Thus, appropriate and specific training, in this instance designed to improving the
activation (i.e., isometric endurance) of the trunk muscles, can influence the onset and
the intensity of musculoskeletal pain arising from physical training (Tavares et al.,
2020).

Given that the specific tasks performed by MPOs whilst wearing and carrying
protective and operational equipment are known to cause back injuries in military
personnel (Knapik et al., 1996; R. Orr et al., 2021), the question arises as to whether
a specific training program for the trunk might reduce their incidence of lower back
pain. The aim of this study was to trial a specific trunk training (TT) program in a
population of MPOs involved in Special Forces Services as a means of reducing the
incidence of musculoskeletal pain without reducing general fitness. It was
hypothesized that a TT program designed to improve trunk muscle endurance would
lead to less musculoskeletal pain whilst not impacting on general fitness. Identifying
the more effective physical training approach is essential to mitigate musculoskeletal
disorders in MPOs Special Force Services and increase physical performance.

Materials and Methods

Subjects

Participants were recruited from the Special Force Police Company, Battalion
of Special Operations, Paraná - Curitiba - Brazil as a sample of convenience. Sixty-
eight percent (n = 37) of all MPOs staff volunteered for the study. Participation criteria
included: a) currently serving in the Special Force Police Company, b) could attend
physical tests, and c) answered the pain scale. Exclusion criteria were: a) a current
injury or illness that prevented them from performing physical tests or physical training,
b) on a continuous treatment of medications that could interfere with the sensation of
musculoskeletal pain; or c) missing more than 20% of physical training sessions or
assessments. The study was approved by the Ethics Committee of the Federal Technological University of Paraná under opinion 2.133.438, with gatekeeper approvals from the immediate Commander. All participants signed the free and informed consent form.

**Study design**

The data collection and intervention lasted for eleven (11) weeks with the first (pre) and last week (post) weeks accounting for the physical and anthropometric tests, and middle nine (09) weeks for the training intervention period. Over the training period, the intervention of a TT program was provided for a group of officers (TTG) while the control group (CG) continued with the habitual or traditional physical training program. Each week, all volunteers filled out the Corlett Diagram (Corlett & Manenica, 1980), which is a pain measurement scale for the different parts of the body.

The formation of the groups took place by the convenience criterion, with the unit naturally divided into two service teams for operational purposes. The randomization happened only between the two service teams to determine the team that would the TTG and the team that would be the CG. The participants kept their administrative or operational activities without interference. The participants, throughout the 11 weeks of research, also reported the number of work missions completed in their respective groups.

Both groups routinely performed 60 minutes of traditional physical training, three times a week, with sessions alternating between aerobic exercises (running on a treadmill or indoor cycling), and exercises that use body weight (squats, lunges, pushups, sit-ups). Sessions were performed at the beginning of the shift. For the
intervention, the TTG had twenty-five minutes of the training time allocated to the TT program.

**Anthropometric measurements**

The MPOs were barefoot wearing only shorts and standing in Frankfurt plane for all anthropometric measurements. Height was measured using a portable stadiometer (Sanny, São Paulo, Brazil), while body mass was recorded by electronic digital scales (Garmin Scale, São Paulo, Brazil). Body mass index (BMI) was calculated as weight (kg) / height (m²).

Waist circumference was measured following one normal expiration. A tape with 0.1 cm precision was placed halfway between the lower border of the ribs, and the iliac crest along a horizontal plane. Hip circumference was measured at the largest perimeter between the waist and the thigh. Circumferences were measured twice with the mean of the two measurements used for analysis. Then waist-to-hip ratio was obtained by dividing the mean waist circumference by the mean hip circumference.

**Trunk endurance test**

To assess trunk endurance, three tests were used, being: i) side plank; ii) double leg lift, and iii) a sit-up test (Figure 1).

[Insert Figure 1 about here]

**The side plank test:** For this test, the participant adopted a lateral side lying position.

On the command to start they lifted their hips off the ground and maintained a
generally straight line while supported on the elbow of the dominant arm with legs extended. The upper foot was placed in front of the lower foot for balance. Time started when the participant adopted the test position. The test was ended when the participant: a) was warned for the 2nd time to return to the initial position, b) gave up due to fatigue, or c) was still holding the position after four minutes. Time in seconds was recorded for statistical analysis (Childs et al., 2010).

The double leg lift test: The participant lay in a supine position with legs extended and arms at the side of the body. When ready the participant’s feet were passively positioned 15 cm from the floor, using the calcaneus as a reference point. From this initial position oscillations of 5 cm upwards or downwards were allowed. The participants were instructed not to push down with their arms during the test. The test was terminated when the participant: a) was warned for the 2nd time to return to the initial position, b) gave up due to fatigue, or c) was still holding the position after four minutes. Time in seconds was recorded for statistical analysis (Childs et al., 2010).

The sit-up test: The participant was instructed to lie on a mat with their knees bent, feet flat on the floor at a distance of 30 cm to 45 cm from the gluteus, and arms crossed with elbows bent over the chest. The participant had their lower limbs fixed to the floor for the duration of the test. One repetition was considered valid and recorded when the participant, starting with the chest on the ground, flexed the trunk until the elbows contacted their thighs and returned to the initial start position. The score consisted of the number of sit-ups that could be completed correctly in sixty seconds (Imai et al., 2014).

Physical performance test
To assess physical performance the following tests were used: i) an agility test (shuttle test), ii) a strength test (pull up), and iii) an aerobic test (12 minutes of walking and running). All participants were familiar with these tests, as they are part of the routine of Special Force Police Company assessment.

The Shuttle Test: This test required the participant to run from one point to another 9.14 m away where they picked up and returned a wooden club on two sequential occasions. The participant stood behind the allocated starting point, with their foot as close as possible to the start line. Upon the voice command of the evaluator, the participant ran at their maximum speed towards two wooden clubs placed after the demarcation line (9.14m). The participant picked up one of the clubs and returned to the starting point, placing that wooden club behind the starting line. Then, without interruption, the participant repeated the process with the second wooden club. Time ceased when the participant placed the last wooden club on the ground and crossed the final line with at least one foot. The wooden club could not be thrown but had to be placed on the ground beyond the border line. Each participant had two attempts at the test with their best time being considered for analysis (Lubas et al., 2018).

Pull up test: The start position had the participant hang from the bar with their arms extended, feet off the ground and hands holding the bar in a pronated grip. To complete a repetition the participant was required to flex their elbows raising their body so that their chin was above the upper part of the bar before returning to the start position with the elbows fully extended. Any contact of the legs or body with any object or aid was not allowed. Only the repetitions correctly executed were counted. The test ended when the participant released their grip from the bar. The
The final number of repetitions completed correctly were used for statistical analysis (Lubas et al., 2018).

**The 12-minute aerobic test:** Participants were required to walk or run, without stopping, as far as possible in 12 minutes. At the end of the test, the distance covered in meters was used for statistical analysis (Lubas et al., 2018).

**Pain measurement scale**

During the 11-week research period, the participants completed the Corlett's Diagram before the start of their workday (Corlett & Manenica, 1980). The diagram is a representation of the posterior part of the human body divided into 22 parts and shows the pain index on a scale ranging from 1 (no pain / no discomfort) to 5 (extreme pain / extreme discomfort).

In order to quantify the subjective responses of pain in the body, the sum of the responses for each of the 22 body segments per week was calculated. Thus, a scale was created, varying from 22, if all answers were 1, to 110, if all answers were 5. Finally, to measure the low back pain report, the response from 1 to 5 of that specific body segment was analyzed.

**Trunk training program**

The participants had 60 minutes of physical training at the beginning of their shift. The current routine had participants perform three sessions a week, combining aerobic exercises (running on a treadmill or indoor cycling) and exercises that use body weight (squats, lunges, push-ups, sit-ups) without progression. This routine was not altered for the CG.
For the TTG, a trunk isometric exercise program was carried out for 9 weeks, 3 times a week, on alternate days. The duration of each session was approximately 25 minutes, with 5 minutes of warm-up; 15 minutes for trunk exercises; and final 5 minutes for recovery. The exercises for warming up and recovery were repeated in all training sessions. In the TTG program, the number of sets increased every three sessions, with new exercises proposed every two weeks. After the TT sessions, the participants in the TTG used the remaining 35 minutes for traditional physical training. Figure 2 summarizes the progression of the training sessions and the exercises used in the TTG.

[Insert Figure 2 about here]

**Statistical analysis**

Descriptive statistics (mean, standard deviation, and frequency) were presented for all variables. The normality of the data was confirmed by the Shapiro Wilk test. Independent sample t-tests were used to compare the mean age, height and length of service between the groups (TTG vs CG). Analysis of variance for repeated measures (two-way ANOVA; 2x2) was used to compare the means between groups (TTG vs CG) and between times (pre vs post intervention) in the trunk endurance tests, physical performance tests and anthropometric measures. Post-hoc Bonferroni adjustment was used to determine where the significance of these variables (p < 0.05). The effect size for the main results was calculated for trunk endurance tests, physical performance tests, and anthropometric measurements using Cohen's $d$. Effect size
was calculated as: Post mean - Pre mean / SD\text{pooled}, where pooled = √[(SD_{post}^2 + SD_{pre}^2) / 2] (Cohen, 1988). Effect sizes were classified as small (0.0 ↔ 1.2), moderate (1.2 ↔ 1.9) or large (> 2.0).

A Friedman’s analysis of variance was used to investigate differences between pain measurement scale results of each group across the 11 weeks of measurement collection. Finally, a Pearson’s correlation (r) was used to determine the levels of association between changes in general pain or lower back pain (LBP) with changes in physical performance (Post-intervention - Pre-intervention). The determination coefficient (r^2) was shown in the significant associations. Alpha levels were set at 0.05 for all analyses.

Results

Thirty-seven participants started the study after signing the informed consent form. However, 17 participants did not meet the inclusion criteria as these participants were transferred from the unit or group for occupational reasons. Therefore, 10 police officers in each group completed all study procedures. The t-test did not reveal significant difference between the TTG and the CG for the variables: height (1.78 ± 0.69 vs 1.76 ± 0.76 meters), years of service in the special unit (8.15 ± 6.02 vs 5.75 ± 2.82 years), and for years of police officer service (11.90 ± 6.21 vs 9.13 ± 2.11 years) but did reveal significant differences in age (33.90 ± 4.15 vs 29.40 ± 3.60 years). Finally, over the 11 weeks of research, the TTG attended a total of 104 work missions and the CG attended a total of 108 work missions.

Table 1 shows the groups’ means for anthropometric variables, the results of the trunk endurance and the physical performance tests. There were significant interactions between group and time for the side plank (F = 31,274; p < 0.001; power =
double leg lift (F = 20,850; p < 0.001; power = 0.991) and pull ups (F = 6,560; p = 0.02; power = 0.678). The performance in the side plank and the double leg lift tests were significantly higher in the post-training TTG when compared to the CG. In addition, the post-training values of the side plank, double leg lift and pull ups were significantly higher than the pre-training scores for the TTG only (+64%, +34% and +24%, respectively). The other variables did not show significant differences.

Over the 11 weeks of research, the results from the Friedman test demonstrated a significant effect for the TTG on ratings of general pain ($\chi^2 = 22.880$, p = 0.011), while the CG did not ($\chi^2 = 11.360$, p = 0.157). These results are shown in Figure 3A. The TTG also reported a significant effect on LBP ($\chi^2 = 26.226$, p = 0.003), while the CG did not ($\chi^2 = 3.649$, p = 0.962). These results are shown in Figure 3B.

Table 2 reveals that increases in LBP were not associated with a rise in general pain ($r = 0.301$; p = 0.197; $r^2 = 0.091$). However, the increase in LBP was significantly associated with the side plank ($r = -0.495$; p = 0.026; $r^2 = 0.245$); double leg lift ($r = -0.475$; p = 0.034; $r^2 = 0.226$) and the shuttle test ($r = 0.613$; p = 0.004; $r^2 = 0.376$). In
turn, the increase in general pain was significantly associated with the side plank ($r = -0.459; p = 0.042; r^2 = 0.211$). The other physical performance variables were not associated with changes in LBP or general pain. Table 2 also shows the associations between trunk endurance tests and physical tests. The double leg lift test was associated with the side plank ($r = 0.625; p = 0.03; r^2 = 0.391$) and with the pull ups ($r = 0.553; p = 0.015; r^2 = 0.306$).

Discussion

This study aimed to determine the impact of a TT program on reported musculoskeletal pain and physical performance of MPOs involved in Special Forces Services. The results show that a TT program led to better performance in double leg lift, side plank (trunk endurance test) and pull up tests (Physical performance test) when compared to CG. Furthermore, the TTG showed superior performance in the trunk endurance tests (double leg lift and side plank tests), between pre- and post-conditions. Of most note, only the TTG showed a significant reduction in general pain and LBP.

The results of this study support previous research. In this study 27 sessions of 25-minute of isometric exercises in plank and bridge postures were sufficient to provide improvements in the performance of trunk endurance tests. This finding is in line with the study by Hoppes et al. (2016) who implemented a trunk training program in a group
of American soldiers. The authors of that study likewise found an improvement in the isometric endurance tests of extensor, flexor and lateral muscles of the trunk.

The improvement in the double leg lift, side plank and pull up tests in the TTG could be explained by the TT program stimulating several muscles in an isometric way during the different plank and bridge postures (such as muscles of the upper and lower limbs) (Childs et al., 2010). In addition, the postures used in the training may also improve the activation and neuromuscular control of the trunk muscles that offer postural stability and synergistic stabilization to better enable neuromuscular performance (Hibbs et al., 2008; Imai et al., 2014; Lum & Barbosa, 2019). The trunk segment plays important roles in posture and movement, including the transfer of energy and the connection of movements between the lower and upper body (Imai et al., 2014). Some studies using specific exercises for the trunk muscles in athletes revealed that segmental movements become more coordinated, which caused reductions in metabolic costs, fatigue and improved performance (Butcher et al., 2007; Hibbs et al., 2008; Kahle & Gribble, 2009; McGill et al., 2015).

On the other hand, the sit-up test, shuttle test and 12-minute aerobic test did not show significant changes in either group, these tests are part of the training routine of these subjects. Thus, as these movements are performed frequently, a greater stimulation (longer training) may be necessary to yield improvements in tests performance (Hibbs et al., 2008; McGill et al., 2015). However, these results suggest that a TT program can be implemented to reduce the incidence of musculoskeletal pain without having a negative impact on general fitness.

MPOs are subjected to long working shifts with associated physical demands that are increased by loads imparted by their mandatory protective equipment (Gruevski et al., 2016; Holmes et al., 2013; Ramstrand et al., 2016). These loads are
known to impact on the trunk and spine (Meakin et al., 2008; Orloff et al., 2004) and have led to injuries in these populations (Orr et al., 2014). Furthermore, the wearing of this protective equipment is known to negatively impact on posture (Orr, et al., 2020). As such, exercises that improve the ability of MPOs to maintain an optimal posture for prolonged periods whilst wearing these loads are important for improving work performance and reducing musculoskeletal pain in this population. The TTG showed not only improvements in trunk endurance and physical tests but also reductions in muscle pain.

The TT program showed a significant effect on general pain and LBP in the TTG. The same was not the case in the CG who continued with the traditional training program. The literature indicates that physical activity developed in the workplace can reduce the report of musculoskeletal pain in workers, however, studies are not clear about which training modalities are most suitable, nor is the duration and intensity of the exercises well described (Silva et al., 2016). More studies are needed to determine the effectiveness of work-related physical activity interventions for arm, elbow, wrist, hand or finger, and low back pain. Furthermore, the effectiveness of an exercise program is determined by factors such as functionality / specificity of movement, intensity / threshold, familiarization and frequency of training (Hibbs et al., 2008; McDonald et al., 2016; McGill et al., 2015). Therefore, differences in findings between studies that have used different models of exercise programs to condition the trunk muscles should be expected and studies need to consider the specifics of their programming approach for their population.

Considering these differences in approaches, the results of the present study are different from those reported by Childs et al. (2010) who did not show a reduction in musculoskeletal pain with the trunk training application. In their study, soldiers
trained four to five times a week for five minutes per training session, totaling twenty to twenty-five minutes of training per week for twelve weeks (totaling 300 minutes of trunk-specific training). In comparison, MPOs in the present study performed about 500 minutes of trunk-specific training. The higher volume of training employed in this study may explain differences in findings between this study and that of Childs et al. (2010).

The results of this study demonstrated that both changes in the sensation of general pain and the sensation of LBP reduced following the TT and were significantly associated with the duration of the side plank test. On the one hand, the literature points to the strength and endurance level of the trunk as one of the predictive factors of LBP (Conway et al., 2016; Mooney et al., 1997). Conversely, Mayer et al., (2016) revealed that the clinical impact on gains in muscle strength and endurance of the lumbar flexor and extensor muscles are not clear for the treatment or prevention of LBP. However, the findings reported in this study revealed that the side plank test had a moderate effect size (1.9) and was sensitive to associated changes in pain. This suggests that monitoring muscles that contribute to lateral flexion of the trunk may be useful to monitor LBP, and pain in general, in this MPO population; especially when general pain is related to police officers who normally wear and carry asymmetric loads on the hips and trunk which in turn are known to cause fatigue and pain (Ramstrand et al., 2016). Discomfort from wearing mandatory equipment has been reported among police during periods of standing and walking and in sitting positions (Larsen et al., 2018; Schram et al., 2018). This is of relevance given that cumulative musculoskeletal discomfort is a known predictor of future musculoskeletal pain and LBP (Larsen et al., 2018; Ramstrand et al., 2016).
A significant positive association was between LBP and the agility test (shuttle test) was identified whereby increases in LBP were associated with increases in time (slowness) taken to complete the agility test. Given the importance of agility in police officers to perform jobs tasks, such as vehicle exits and foot pursuits (Lubas et al., 2018), these findings demonstrates that LBP can have negative impacts on police task performance. Further adding to this concern is research highlighting how loads carried by police can negatively impact on their agility and change of direction speed (Joseph et al., 2018; Lubas et al., 2018; Violanti et al., 2017).

The possible limitations of this study should be presented for a better critical interpretation of the findings and to assist future studies. The sample size was restricted to twenty elite military police officers; a limitation common in specialist police units (Schram et al., 2020). As such, while the results were considered to be reliable due to the power of ANOVA (between 0.678 and 1.000) and the effect sizes showing variations from small to moderate, the trunk training program, as well as its results, may be limited in their transferability to other general duties police officers. However, MPOs classified in the Special Operations Battalion are a highly trained elite group, constituting 0.3% of police in Brazil. More specifically in the state of Paraná, there is a total of 54 MPOs in this classification, of which 37% participated in our study. Thus, while the sample size is small, it does represent a notable percentage of this specialist population. In a global context, other law enforcement specialist units, who likewise carry out tasks of high operational risk and, due to their high financial cost and strict staff selection, consist of a small number of officers, may benefit from the findings of this study. These international units include Batalhão de Operações Especiais (BOPE) in Brazil; Recherche, Assistance, Intervention, Dissuasion (RAID) in France; Special Weapons and Tactics (SWAT) in the United States; GSG9 der Bundespolizei in
Germany; Special Suppressive Antiterrorist Unit (EKAM) in Greece; Yehidat Mishtara Meyuhedet (YAMAM) in Israel; Gruppo di Intervento Speciale (GIS) in Italy; Grupo de Operaciones Especiales (GOPES) in Mexico, Grupo de Operações Especiais (GOE) in Portugal, the Police Tactical Group (PTG) in Australia.

The researchers involved in this study had no control over the routine activities of the MPO participants due to ethical and legal aspects. Therefore, despite the similar number of mission occurrences between the groups mission durations or subsequent physical and mental stresses were not available for consideration. In addition, participants carried out exhaustive technical-tactical training as part of their normal duties, which could have interfered with their overall physical conditioning (Orr et al., 2016). However, the two groups are under the same command structure, operate in the same region, and the weekly routine of technical-tactical training and occurrences types were similar. More importantly, this research presents real-world and pragmatic findings, such as would be expected of the population in normal working conditions.

Conclusion

The findings of this study highlight that TT can reduce the perception of general musculoskeletal pain and LBP and increase the isometric endurance of the trunk muscles without a concomitant loss in general fitness, in a population of MPO. The side plank test score was the only test associated with LBP and general musculoskeletal pain. Future research could explore this finding and whether the side plank test could be used as a tool to predict the onset of pain or could be used as part of return-to-work test following injury for this population. Finally, MPOs, and other specialist police units, may benefit from a TT program to mitigate pain and LBP specifically.
CONFLICT OF INTEREST
The authors declare no conflict of interest.

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Violanti, J. M., Ma, C. C., Fekedulegn, D., Andrew, M. E., Gu, J. K., Hartley, T. A.,...


Title and Legend

Figure 1: Description of the trunk endurance tests

Figure 2: 9-week Trunk Training Program applied to Military Police Officers

Figure 3: Pain measurement scale for the Control Group and Trunk Training Group over 11 weeks.

Legend: π = different from pre-training; † = different from week 1; & = different from week 9; #= different from post-training

TABLE 1_ Anthropometric, trunk endurance and physical test descriptive data and inferential results

Legend: * = different from control group (p < 0.05); π = different from pre-training of same group.

Table 2- Correlation coefficients (Pearson r) between absolute change pre- and post-intervention for trunk endurance and physical performance test variables

Legend: @ = p < 0.05: LBP= low back pain: G_pain = general pain: S_plank = side plank: D_Leg = double leg lift: Sit-up = The sit-up test: Shuttle = shuttle test: 12 min = 12 mins aerobic walk / run for distance test.
<table>
<thead>
<tr>
<th>Measure</th>
<th>Trunk Training Group</th>
<th>Control Group</th>
<th>Cohen's d (95% IC)</th>
<th>Cohen's d (95% IC)</th>
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<td>Weight (kg)</td>
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<td>90.30 ± 12.19</td>
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<td>0.0</td>
</tr>
<tr>
<td>Waist to hip ratio</td>
<td>0.91 ± 0.06</td>
<td>0.89 ± 0.05</td>
<td>0.0</td>
<td>-0.9 ↔ 0.9</td>
</tr>
<tr>
<td>Side Plank (s)</td>
<td>68.80 ± 17.00</td>
<td>109.40 ± 27.00(^{**})</td>
<td>1.9 (0.7 ↔ 2.8)</td>
<td>0.5 (0.4 ↔ 1.3)</td>
</tr>
<tr>
<td>Double leg lifts (s)</td>
<td>117.00 ± 39.05</td>
<td>157.10 ± 42.61(^{**})</td>
<td>1.3 (0.7 ↔ 2.2)</td>
<td>-0.5 (-1.4 ↔ 0.4)</td>
</tr>
<tr>
<td>The sit-up test (rep)</td>
<td>49.70 ± 12.06</td>
<td>55.10 ± 15.34</td>
<td>0.3 (0.6 ↔ 1.1)</td>
<td>-0.9 ↔ 0.9</td>
</tr>
<tr>
<td>Shuttle test (s)</td>
<td>10.53 ± 0.85</td>
<td>10.3 ± 0.8</td>
<td>-0.2 (-1.1 ↔ 0.6)</td>
<td>0.0 (0.9 ↔ 0.9)</td>
</tr>
<tr>
<td>Pull ups (rep)</td>
<td>8.00 ± 2.79</td>
<td>9.90 ± 2.85(^{**})</td>
<td>0.7 (-0.2 ↔ 1.5)</td>
<td>-0.1 (-1.0 ↔ 0.8)</td>
</tr>
<tr>
<td>12-minute test (m)</td>
<td>2325.00 ± 201.45</td>
<td>2402.00 ± 233.32</td>
<td>0.3 (-0.5 ↔ 1.2)</td>
<td>0.1 (-0.8 ↔ 1.0)</td>
</tr>
<tr>
<td></td>
<td>LBP</td>
<td>G_Pain</td>
<td>S_plank</td>
<td>D_leg</td>
</tr>
<tr>
<td>------</td>
<td>-----</td>
<td>--------</td>
<td>---------</td>
<td>-------</td>
</tr>
<tr>
<td>LBP</td>
<td>1</td>
<td>0.301</td>
<td>-0.495</td>
<td>-0.475</td>
</tr>
<tr>
<td>G_Pain</td>
<td>1</td>
<td>-0.459</td>
<td>-0.143</td>
<td>0.042</td>
</tr>
<tr>
<td>S_plank</td>
<td>1</td>
<td>0.625</td>
<td>0.124</td>
<td></td>
</tr>
<tr>
<td>D_leg</td>
<td>1</td>
<td>0.435</td>
<td></td>
<td>-0.193</td>
</tr>
<tr>
<td>Sit-up</td>
<td></td>
<td></td>
<td>-0.141</td>
<td></td>
</tr>
<tr>
<td>Shuttle</td>
<td></td>
<td></td>
<td>-0.331</td>
<td></td>
</tr>
<tr>
<td>Pull ups</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 min</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 1 Caption: Description of the trunk endurance tests. Figure 1 Alt Text: "Photographs of people performing the trunk endurance tests. The photo in upper right of the picture demonstrates the side plank test. The photo in upper left of the picture demonstrates the leg lifts test. Both photos in the bottom show the start and end position of the sit-up test.

235x171mm (72 x 72 DPI)
Figure 2 Caption: 9-week Trunk Training Program applied to Military Police Officers

<table>
<thead>
<tr>
<th>Exercises</th>
<th>Training session duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front Plank</td>
<td>16 minutes</td>
</tr>
<tr>
<td>Single Leg Front Plank</td>
<td>16 minutes</td>
</tr>
<tr>
<td>Side Plank</td>
<td>17 minutes</td>
</tr>
<tr>
<td>Single Leg Bridge</td>
<td>17 minutes</td>
</tr>
<tr>
<td>Side Plank with arm raise</td>
<td>17 minutes</td>
</tr>
<tr>
<td>Brit Dog</td>
<td>16 minutes</td>
</tr>
<tr>
<td>Dorsal Raise</td>
<td>17 minutes</td>
</tr>
<tr>
<td>V-up</td>
<td>17 minutes</td>
</tr>
<tr>
<td>Cervical Flex Front Plank</td>
<td>17 minutes</td>
</tr>
<tr>
<td>Tip Toe Bridge</td>
<td>17 minutes</td>
</tr>
<tr>
<td>Side Plank with arm raise</td>
<td>17 minutes</td>
</tr>
<tr>
<td>Side Plank with perturbations</td>
<td>16 minutes</td>
</tr>
</tbody>
</table>

**General information**
- Warning up = 2 min jump rope; 2 min running in place; 10 burpees.
- 30 s interval rest between sets
- 45 s interval rest between exercises

Fifteen descriptive photographs of the exercises used for the Trunk Training Program applied to Military Police Officers

150x234mm (72 x 72 DPI)
Figure 3 Caption: Pain measurement scale for the Control Group and Trunk Training Group over 11 weeks. / \( n \) = different from pre-training; \( \dagger \) = different from week 1; \( \& \) = different from week 9; \( \# \) = different from post-training. Figure 3 Alt text: Box plot graphics show the results of general pains (upper area) and low back pain at the experimental and control groups. There were a decrease of pains only in the experimental group.

168x166mm (300 x 300 DPI)