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Chronic Ankle Instability and Neuromuscular Performance in Prerecruitment Infantry Soldiers

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Context: Ankle instability can describe various impairments, including perceived instability (PI), mechanical instability (MI), and recurrent sprains (RSs), alone or combined.

Objective: To examine the prevalence of 8 ankle impairment subgroups and their effect on neuromuscular performance in prerecruitment combat soldiers.

Design: Cross-sectional study.

Setting: Military infantry basic training base.

Patients or Other Participants: A total of 364 infantry male combat soldiers entering basic training (aged 18–21 years).

Main Outcome Measure(s): Participants were assessed for PI (via the Cumberland Ankle Instability Tool), MI (using the Anterior Drawer Test and Medial Talar Tilt Test), and RSs (based on history) of their dominant and nondominant legs. Injuries were categorized in 8 subgroups: PI, RSs, PI + RSs, MI, PI + MI, MI + RSs, PI + MI + RSs, and none. Participants were screened for neuromuscular performance (dynamic postural balance, proprioceptive ability, hopping agility, and triceps surae muscle strength) during the first week of military basic training.

Results: For the dominant and nondominant legs, RSs were reported by 18.4% (n = 67) and 20.3% (n = 74) of the participants, respectively; PI was reported by 27.1% (n = 99) and 28.5% (n = 104) of the participants, respectively; and MI was seen in 9.9% (n = 36) and 8.5% (n = 31) of the participants, respectively. A 1-way analysis of variance showed differences in the mean proprioceptive ability scores (assessed using the Active Movement Extent Discrimination Apparatus) of all subgroups with impairments in both the dominant and nondominant legs ($F = 6.943$, $\eta^2 = 0.081$, $P < .001$ and $F = 7.871$, $\eta^2 = 0.091$, $P < .001$, respectively). Finally, differences were found in the mean muscle strength of subgroups with impairment in the nondominant leg ($F = 4.884$, $\eta^2 = 0.056$, $P = .001$).

Conclusions: A high prevalence of ankle impairments was identified among participants who exhibited reduced abilities in most neuromuscular assessments compared with those who did not have impairments. Moreover, participants with 1 impairment (PI, MI, or RSs) exhibited different neuromuscular performance deficits than those with >1 impairment.

Key Words: postural balance, proprioception, agility, muscle strength

Key Points

- We examined the prevalence of a range of ankle impairments in 364 prerecruitment infantry soldiers entering basic training and their effects on neuromuscular performance.
- A high prevalence of ankle impairments (perceived instability, mechanical instability, and recurrent sprains) was identified among participants.
- Soldiers with ankle impairments presented reduced neuromuscular abilities compared with those who had no such impairments.
- Soldiers with only 1 ankle impairment exhibited different neuromuscular deficits than those with a combination of impairments.

High levels of neuromuscular performance are required for soldiers to successfully carry out operational activities and other challenging military tasks, such as traversing rocky terrain or rapidly disembarking from a vehicle while bearing a substantial load. Investigators have indicated that soldiers with advanced neuromuscular performance abilities (such as strong postural balance, proprioceptive acuity, appropriate agility, and suitable muscle strength) can endure prolonged periods of training while exhibiting good motor skills in the field.[1] However, individuals with reduced neuromuscular abilities might be at an increased risk for lower extremity musculoskeletal injuries, especially ankle sprains.[2]

Repetitive ankle sprains or inadequate rehabilitation or both after a sprain could contribute to the development of *chronic ankle instability* (CAI), which is defined as "a condition characterized by repetitive episodes or perceptions of the ankle giving way; ongoing symptoms such as pain, weakness, or reduced ankle range of motion; diminished self-reported function; and recurrent ankle sprains that persist for more than 1 year after the initial injury."[3(p572)] Authors of literature reviews noted that evaluating CAI was not simple, as the term *CAI* has been used to describe a range of related and persistent limitations.[4] In most cases, the presence of CAI is determined by looking for subsequent sprains,[4] functional or perceived ankle instability (ie, ankle weakness, instability, or giving way),[5] or greater ankle joint laxity or a combination of these.[6] In 2011, Hiller et al[5] presented a model that consisted of the main ankle impairments, terming them *recurrent sprains* (RSs), *mechanical instability* (MI), and *perceived instability* (PI). Each of these impairments can exist independently or in combination with other impairments. As such, individuals can suffer from PI without experiencing RSs.[5] Combinations of these 3 impairment types resulted in 7 subgroups (PI, RSs, PI + RSs, MI, PI + MI, MI + RSs, and PI + MI + RSs).[5]

Moreover, individuals with ankle impairments may also display altered neuromuscular performance, such as reduced muscle strength, proprioceptive ability, and postural balance and other altered performance measures.[7,8] In soldiers, special care should be taken when screening for ankle instability and reduced neuromuscular performance, as both phenomena increase the risk of lower limb musculoskeletal injuries.[9] Yavnai et al,[10] for example, showed that neuromuscular impairments and PI were major contributing factors to injuries during commander courses. Moreover, Nagai et al[11] found that soldiers who developed ankle injuries during 1 year of military service demonstrated lower baseline neuromuscular performance abilities and were at a higher risk of further musculoskeletal injuries than soldiers who did not develop such injuries.

However, limited evidence exists for the relative contributions of different ankle impairments to neuromuscular performance ability and restrictions in soldiers before they embark on demanding long-term infantry training.[12] The aim of our study, therefore, was to examine the prevalence of the 7 subgroups of ankle impairments among infantry soldiers entering basic training, while examining the relationships between the subgroups and participants' neuromuscular performance ability, assessed through postural balance, proprioceptive ability, hopping agility, and muscle strength. Increased understanding of these impairments will improve our capacity to develop interventions for this population.

METHODS

Participants

The sample was newly recruited soldiers who agreed to participate voluntarily. All participants had joined the military in March 2022 and been assigned to infantry basic training. Before recruitment, each participant had passed medical screenings for his or her future training, structured in line with military requirements, including physical exercise, marching and obstacle courses, the use of firearms, and field orientation while carrying heavy loads. (However, the training program was not part of this study.)

Table 1. Eight Impairment Subgroups

PI
RSs
PI + RSs
MI
PI + MI
MI + RSs
PI + MI + RSs
None

Abbreviations: MI, mechanical instability; PI, perceived instability; RSs, recurrent sprains.

Research Recruitment Process

All soldiers who were about to embark on the infantry basic training course were included in the initial recruitment, during which they were provided with the research aims and procedure. Emphasis was placed on the following conditions: (1) participants could choose whether or not to join the research program, (2) their commanders would not have access to any of their individual results, (3) individuals who chose not to participate in the research would not be penalized, and (4) participants could withdraw from the study at any time without having to provide an explanation to their commanders or the research team. Participants were informed of the risks and benefits of the study before data collection, and they signed informed consent forms. The study was approved by the institutional review board (No. 2251-2021). As participants had already undergone medical screening by the military and were found to have no physical or medical health impediments, no physical exclusion criteria were applied in this study.

Data Collection

Data were collected over several days, at the onset of the soldiers' basic training course and on their basic training base. Participants were assessed for 3 aspects in pseudorandomized order: (1) anthropometric measures, (2) neuromuscular performance abilities (by 3 professional trainers), and (3) ankle instability (MI was assessed by 2 experienced sport physiotherapists). *Anthropometric measures* were height, weight, and leg length (measured from the anterior-superior iliac spine to the distal end of the medial malleolus). Body mass index (BMI) was also calculated. Four aspects of *neuromuscular performance abilities* were assessed: (1) dynamic postural balance, (2) proprioceptive ability, (3) hopping agility, and (4) triceps surae muscle strength. *Ankle impairments* were evaluated discreetly for the dominant and nondominant leg, based on 3 impairments: PI, RSs, and MI. Participants were then divided into 8 subgroups: PI, RSs, PI + RSs, MI, PI + MI, MI + RSs, PI + MI + RSs, and none of these impairments (Table 1). Due to the small number of participants with MI, we combined the groups with MI, PI + MI, MI + RS, and PI + MI + RS for analysis purposes.

To determine each participant's dominant leg, he or she was asked to kick a ball; the *dominant leg* was defined as the weight-bearing leg when he or she kicked the ball (and the preferred hopping leg). Participants performed all tests barefoot while wearing army uniforms.

Neuromuscular Performance Abilities. ***(1) Dynamic Postural Balance.*** Participants were asked to perform the

Y-Balance Test (YBT) for each leg, as previously described in soldiers.[13] The professional athletic trainers who conducted this assessment were highly familiar with the YBT and had been using it clinically for the past 5 years. First, participants were asked to complete 4 practice trials in 3 directions (anterior, posterior-lateral, and posterior-medial) and for each leg; after a 2-minute resting period, they then immediately performed 3 test trials in all 3 directions.[13] The composite score was calculated as the sum of the reached distances in the 3 directions, divided by 3 times the limb length, and multiplied by 100. The composite scores of the dominant and nondominant legs were recorded for each person.

(2) Proprioceptive Ability. The Active Movement Extent Discrimination Apparatus (AMEDA) was used for this assessment.[14,15] The professional athletic trainers who performed these assessments were highly familiar with the AMEDA and had been clinically using it over the past 5 years. This test is designed to evaluate the participant's sensitivity to small differences in ankle-inversion movements during normal weight-bearing stance. The device comprises a fixed plate for the nontested leg and a swinging plate that rotates around an axle for the tested leg. Starting in the standing position, the individual places equal weight on both legs, with the nontested foot on the fixed plate and the tested foot on the swinging plate. He or she is then asked to perform an active ankle-inversion movement, which drops 1 side of the plate until it reaches a metal stop. The stopping position can be adjusted to different heights between trials. The participant must then return the plate to the horizontal position using the foot and report the perceived extent of inversion. The test consists of 5 positions (ie, different angles from the horizontal position): 10.49°, 11.84°, 12.55°, 13.27°, and 14.52°, numbered 1 through 5, respectively. Participants were asked to perform 3 introduction cycles, each with all 5 test positions in sequence. Next, they were asked to perform 50 ankle-inversion movements, with each of the 5 angles being presented 10 times in random order. After each movement, the individual reported at which of the 5 angles he or she felt the foot was positioned. The AMEDA test was performed on the dominant leg only.

(3) Hopping Agility. In this test, a hexagon with 60-cm sides was marked on the floor, with a 40-cm diameter circle marked inside.[15] Participants were asked to stand on 1 leg inside the marked circle, hop forward outside the borders of the hexagon, and then immediately hop back inside the circle borders. They were instructed to perform this task without touching the outline of the hexagon and while facing the examiner throughout, resulting in their hopping forward, sideways, and backward. This process was repeated in a clockwise manner for 10 continuous seconds and immediately followed by the same process in a counterclockwise direction for an additional 10 seconds, without stopping when changing direction. Participants completed this task for each leg individually. The examiner counted the number of times each person successfully hopped in and out of the circle, without touching the hexagon outline, for each leg and in both directions.[15] The aim of this hexagon test is to measure speed, power, and agility. The average score for the 4 tests (both legs and both directions) was used as the final score for each participant.

(4) Triceps Surae Muscle Strength. For this assessment, the bilateral heel-raise test was used, in line with previous researchers who conducted it to evaluate foot and ankle functional performance after a variety of injuries such as ankle sprains.[16] The participant was asked to stand facing the wall and was allowed to touch the wall during the test for balance purposes, if needed. He or she was then instructed to raise both heels to stand as tall as possible. The maximal height with raised heels was recorded, and the individual was then asked to continuously raise and lower the heels at a consistent rate of 40 repetitions per minute (determined by a metronome) as many times as possible, while achieving maximal height each time. The test ended when the person was either too tired to continue or unable to maintain the pace. The examiner counted the number of heels raises in which each participant reached the maximum height.

Ankle Impairment Assessments. ***(1) Perceived Instability.*** Participants were asked to complete the 9-item Cumberland Ankle Instability Tool (CAIT) questionnaire. The maximum score is 30, and a score $\leq$25 indicates PI.[17] All participants were categorized as either *with PI* or *no PI*.

(2) Recurrent Sprains. Each participant was first assessed by an orthopaedic physician regarding previous and recurrent ankle sprains and then asked to complete a questionnaire about previous ankle sprains. Those who reported $\geq$2 sprains over the past 2 years were categorized as having RSs; the incidence of recurrence can be altered over as short a timeframe as 1 year,[18] and RSs during an even shorter timeframe have been considered appropriate for identifying CAI.[19] However, since an individual's more recent history of frequent giving way and RSs are captured in the CAIT score,[17] we chose to broaden the sprain history to 2 years to capture longer-term recurrences. All participants were categorized as either *with RSs* or *no RSs*.

(3) Mechanical Instability. For this assessment, the anterior drawer test (ADT) and medial talar tilt test were used. The ADT was primarily designed to assess the anterior talofibular ligament, the most frequently injured ligament in the ankle. The participant was asked to lie in the supine position, with the knees relaxed and ankles in 10° to 20° of plantar flexion. The examiner held the participant's calcaneus in 1 hand while fixating the anterior part of the distal tibia with the other. The foot was then drawn anteriorly until no further movement was possible.[20] A positive ADT may indicate a tear of the anterior talofibular ligament, but if the calcaneofibular ligament is also torn, the anterior translation is greater. In the medial talar tilt test, the participant is in a supine position, with the knee in slight flexion. The examiner stabilizes the fibula and tibia with the proximal hand and, with the distal hand, moves the calcaneus and talus as a unit to an inversion position. Earlier authors demonstrated that an experienced clinician can discriminate meaningful ligamentous laxity and that this is related to functional performance.[15] The scale for both tests is 1 = *stable*, 2 = *partially unstable*, and 3 = *completely unstable* (rated in the current study on a scale of 0–2).[20] Participants were categorized as *no MI* (0 or 1) or *with MI* (2). The intertester reliability of these observations was examined based on 20 participants, whereby 2 physiotherapists carried out measurements on the same participants within an hour using the same method. Testers were not exposed to their colleagues' assessment outcomes. Reliability indices showed $\kappa = 0.78$ ($P < .001$).

Data Analysis

For the anthropometric variables, means and SDs are presented. Ankle impairments (PI, RSs, and MI) in the dominant or nondominant leg (or bilateral) were recorded for each participant. The 8 subgroups (divided separately into dominant and nondominant leg groups) were PI, RSs, PI + RSs, MI, PI + MI, MI + RSs, PI + MI + RSs, and no impairment (Table 1). Three of the 4 neuromuscular measures had only 1 score recorded for each person: the AMEDA was recorded for the combined-legs only, the hexagon hop test was recorded as a combined-legs score, the heel raise was performed on both legs simultaneously, and the YBT was recorded for the dominant and nondominant legs separately. Separate 1-way analyses of variance were used to compare the 5 groups (PI, RSs, PI + RSs, MI + other[s], none) for the anthropometric and neuromuscular performance variables. Testing for normality was conducted using the Shapiro-Wilk test. Adjustments for multiple comparisons was made using Bonferroni corrections. Means and 95% CIs were plotted for the ankle impairment variables. Analyses were carried out separately for the dominant and nondominant legs. Post hoc 2-tailed *t* tests were used to identify the differences found between specific groups for any main effects. When participants did not complete all tests, their assessments and scores were not included in our analysis. Statistical analyses were performed using SPSS (version 26.0; IBM Corp), and the significance level for all statistical tests was set at $\alpha = .05$.

RESULTS

Findings regarding the anthropometric measures for the 364 participants were as follows: height = 175.5 ± 6.6 cm, weight = 75.2 ± 12.4 kg, and BMI = 24.4 ± 3.6 kg/m^2.

The number of participants in the 7 impairment subgroups are provided in Figure 1. For the dominant and nondominant legs, RSs were reported by 18.4% (n = 67) and 20.3% (n = 74) of participants, respectively; bilateral RSs by 10.7%; PI by 27.1% (n = 99) and 28.5% (n = 104), respectively; and bilateral PI by 24.7%. Mechanical instability in the dominant and nondominant legs was noted in 9.9% (n = 36) and 8.5% (n = 31) of the participants, respectively, and bilateral MI in 2.7%.

We found differences in the mean height of participants in the various subgroups ($F = 2.664$, $\eta^2 = 0.030$, $P = .032$), whereby participants with PI + RSs were taller than those without impairment. No differences were evident in the weights and BMIs by group.

The means and 95% CIs of the neuromuscular performance abilities in the 5 subgroups (recorded separately for the dominant and nondominant legs) are given in Table 2. The mean AMEDA scores differed among the subgroups with impairments in the dominant leg ($F = 6.943$, $\eta^2 = 0.081$, $P < .001$) and the nondominant leg ($F = 7.871$, $\eta^2 = 0.091$, $P < .0010$). For the heel-raise test, differences occurred among the subgroups with impairments in the nondominant leg ($F = 4.884$, $\eta^2 = 0.056$, $P = .001$) but not the dominant leg. The YBT and hopping agility tests demonstrated no differences among the subgroups with impairments in either leg (Table 2; Figure 2).

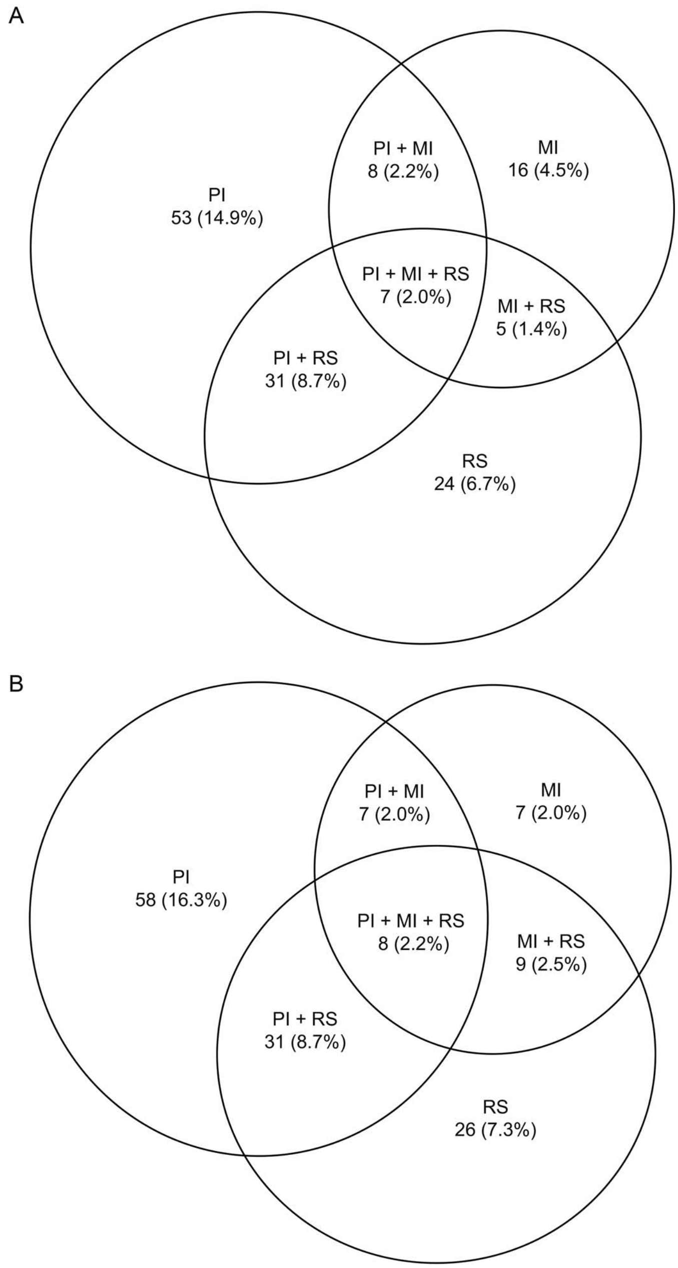

Figure 1. The prevalence of participants in the 7 subgroups for A, dominant and B, nondominant legs. Subgroups consisted of individuals with (A) perceived instability (PI); (B) recurrent sprains (RSs); (C) PI and RSs; (D) mechanical instability (MI); (E) PI and MI; (F) MI and RSs; and (G) PI, MI, and RSs.

DISCUSSION

Our results indicated a high prevalence of ankle impairments among participants who were newly recruited into infantry basic training. Recurrent sprains were reported by around one-fifth of the participants, and PI by nearly one-third. A combination of MI-related impairments was seen in about 1 in 10 participants. When comparing the neuromuscular performance ability of the 5 impairment subgroups, we observed differences in their proprioceptive ability and triceps surae muscle strength. Furthermore, individuals with a certain impairment exhibited different neuromuscular deficits than those with another impairment or with several impairments combined. Identifying ankle

Table 2. Neuromuscular Performance Abilities of the Dominant and Nondominant Legs in the 5 Impairment Subgroups

Leg, Test	Impairment, Mean (95% CI)					$P < .05$[a]
	PI	RSs	PI + RSs	MI	None	
Dominant						
AMEDA	0.635 (0.619, 0.651)	0.654 (0.629, 0.678)	0.659 (0.638, 0.680)	0.615 (0.595, 0.635)	0.665 (0.657, 0.673)	1–9
Heel rise	43.5 (36.1, 50.9)	41.3 (29.7, 52.8)	42.7 (32.8, 52.5)	39.6 (30.2, 49.0)	48.3 (44.4, 52.1)	1–4
YBT	82.8 (80.3, 85.4)	83.7 (79.7, 87.6)	82.1 (78.7, 85.4)	82.43 (79.2, 5.6)	84.9 (83.6, 86.2)	1,3,4
Hexagon	5.81 (5.24, 6.4)	6.52 (5.7, 7.4)	5.86 (5.0, 6.6)	5.56 (4.5, 6.3)	6.18 (5.9, 6.5)	1–5,9
Nondominant						
AMEDA	0.632 (0.617, 0.648)	0.645 (0.623, 0.668)	0.666 (0.645, 0.687)	0.616 (0.596, 0.637)	0.666 (0.658, 0.675)	1,2,4,6,8,9
Heel rise	36.7 (29.6, 43.7)	36.2 (25.7, 46.8)	38.5 (28.8, 48.1)	56.6 (47.2, 66.2)	48.9 (45.1, 52.7)	1–3,7–9
YBT	81.69 (79.0, 84.3)	84.43 (80.4, 88.4)	82.17 (78.6, 85.7)	82.86 (79.3, 86.4)	84.4 (83.1, 85.9)	1,3–5
Hexagon	5.39 (4.9, 5.9)	5.82 (5.0, 6.6)	5.42 (4.7, 6.2)	6.07 (5.3, 6.8)	6.09 (5.8, 6.4)	1,3,7

Abbreviations: AMEDA, Active Movement Extent Discrimination Assessment; MI, mechanical instability; PI, perceived instability; RSs, recurrent sprains; YBT, Y-Balance Test.

[a] Differences indicated via 2-tailed *t* tests: 1 = PI vs none; 2 = RSs vs none; 3 = PI + RSs vs none; 4 = MI vs none; 5 = PI vs RSs; 6 = PI vs PI + RSs; 7 = PI vs MI; 8 = RSs vs MI; 9 = PI + RSs vs MI.

impairments at the onset of soldiers' military service, especially before they embark on combat basic training, is of the utmost importance, as a previous ankle sprain is a significant risk factor for future ankle sprains.[21] Moreover, first-year military cadets with a history of ankle sprains are at about a 3.5 times higher risk of additional sprains than those with no such history, which puts them at greater risk for CAI.[22]

The high prevalence of participants with 1 or more ankle impairments was in line with the existing literature. Among military populations, the most frequently reported lower extremity injuries included ankle sprains and CAI[22–24]—a prevalence that could be 5 to 8 times higher than in civilian populations.[25] When healthy participants were similarly subgrouped, 42.6% were classified with PI, 30.5% with RSs + PI, and 26.9% with other impairments.[5] However, Hershkovich et al[26] noted a prevalence of only 0.7% for mild CAI and 0.4% for severe instability in young adults before their recruitment into mandatory military service. These varied findings could stem from the different methods of assessment (ie, self-reporting questionnaires rather than the physical assessments or in-person reporting in our study). Moreover, different inclusion or exclusion criteria for CAI could also have been factors.[27]

Considering the relationship between ankle impairments and reduced neuromuscular abilities, participants with 1 impairment exhibited different neuromuscular deficits than those with another impairment or several impairments. Participants with RSs, for example, presented reduced neuromuscular performance abilities versus those with no impairments, yet participants with RSs exhibited better abilities than those with PI. No consistency was found between the neuromuscular performance ability of participants with only RSs or only PI versus participants with MI and additional impairments. The rationale for assessing neuromuscular performance abilities in the subgroups stemmed from the literature in which authors have emphasized its necessity, as each subgroup exhibited different deficits or different levels of severity.[5] Furthermore, our findings of reduced neuromuscular ability in infantry soldiers entering basic training with ankle impairments are similar to previous outcomes in athletes and nonmilitary populations.[28] For instance, adolescent elite athletes with a history of ankle sprains demonstrated impaired, 1-legged landing balance after jump landings,[29] and postural balance and stabilization maneuver tests detected differences between individuals with and those without CAI. Researchers have also indicated that individuals with MI displayed deficits in the single-hop distance test, hexagon-hop test, and proprioceptive ability.[30,31] In a comparable subgrouping of ankle impairments, individuals with PI had a range of additional instabilities, in different constellations, and RSs were associated with reduced balance.[32] Hiller et al[4] reported that participants with ankle impairments showed decreased postural balance and a reduced ability to recover from perturbation tasks than those without such impairments. Additionally, individuals with PI had greater impairment in single-legged stance, whereas participants with RSs exhibited reduced postural balance compared with other subgroups. The authors also found that individuals with no MI (hypomobility) had the best ability to recover from perturbation.[5] However, not all authors determined that neuromuscular performance tests were effective in detecting differences between participants with and those without ankle impairments.[32,33]

In premilitary recruits, extensive attention should be given to assessing neuromuscular ability, as such decreased abilities were a significant predictor of future ankle sprains and other musculoskeletal injuries.[11,34–37] Yet limited data have been presented on this specific population, and as such, few comparisons with our results can be made. In line with our outcomes, Witchalls et al[14] stated that impaired PI (low CAIT scores) was related to reduced agility performance and reduced postural ability in combat commander courses. Our findings could be explained by the relatively small number of soldiers who were identified with RSs. Still, not all RSs lead to additional CAI impairments.[3] Perhaps soldiers who self-report PI impairments are more likely to display such deficits than participants with a history of ankle sprains from which they have fully recovered.

Our results indicate that, although a history of ankle sprains is important, it is not the primary determinant of current levels of function in participants with CAI. Self-rating PI and MI outcomes have demonstrated more wide-reaching associations with current functional levels. Furthermore, individuals with MI or PI could present different outcomes due to variations in diagnostic measures and assessment reliability and standards.[20] Wenning et al,[38] who

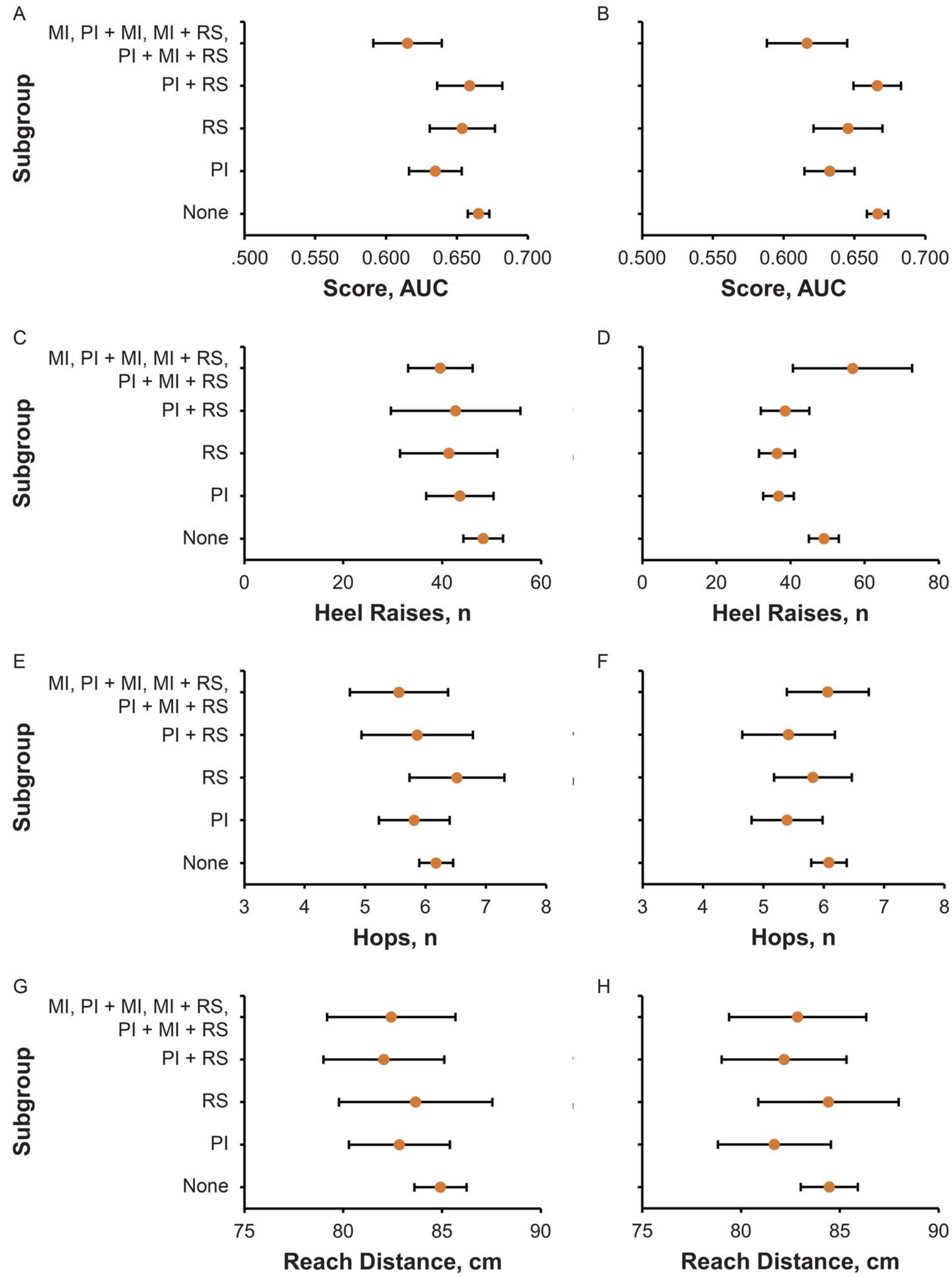

Figure 2. Means (orange circle) and 95.0% lower and upper CIs (lines) of neuromuscular performance abilities (Active Movement Extent Discrimination Apparatus [AMEDA] scores, heel rise, hexagon-hop test, and Y-Balance Test [YBT]) of soldiers in the different subgroups of ankle impairments. Abbreviations: AUC, area under the curve; MI, mechanical instability; PI, perceived instability; RS, recurrent sprain.

observed strong correlations between PI (via the CAIT questionnaire) and MI (via clinical assessments), argued that the severity of 1 measure of impairment correlated with the severity of a mechanical, perceived, or functional instability that was measured either clinically or via objective methods.[3,38] Nonetheless, relationships between different ankle impairment subgroups in military recruits have not been examined.

Assessing several aspects of neuromuscular ability of the ankle region may provide more comprehensive information regarding the patient's abilities than a single test (eg, postural balance).[14] We acknowledge that our tests were military-specific movements, with relevant loads on the ankle joint that require balance, proprioception, coordination, agility, strength, and multiplanar neuromuscular stabilization to perform high-intensity activities.[13,14] Neuromuscular performance tests have been described as complex tasks that require multiple joints and structures to produce movements that may lead to compensatory responses.[39] As such, future authors should consider evaluating additional demanding military activities that specifically affect functional tasks and stress the ankle joint. Future researchers could also follow soldiers' injuries during their military service. Although we conducted no follow-up of related injuries during participants' basic training, other investigators have identified similar neuromuscular and somatosensory deficits (such as reduced proprioceptive ability and postural balance deficits) as factors that greatly contribute to injuries during military training.[11,34,35]

Despite the large number of soldiers assessed (more than 350 participants), the small sample sizes of the MI subgroups limited our ability to statistically analyze all 8 subgroups individually. Because the subgroups were small, we combined the hypomobile category (according to Hiller et al[5]) with those who had normal ankles and defined them as participants with no MI (part of the subgroup with no impairment); we then compared them with participants who had hypermobile ankles as defined with MI (subgroups MI, PI + MI, MI + RSs, and PI + MI + RSs). Certain variables were analyzed with data from fewer than 364 participants, as some soldiers missed 1 or 2 of the screening assessments (due to guard duty, kitchen duty, etc). Time constraints restricted the AMEDA testing to the dominant leg only. For the ADT and medial talar tilt test, no instrumented assessment was possible. Although all participants were medically screened for military service and declared healthy in terms of musculoskeletal structures, we were unable to control for a history of injury to other joints of the lower limbs.

Clinical Implications

This study has a number of important clinical implications. First, clinicians, medical staff, and military commanders should be aware of the high prevalence of ankle impairments among recruits and their related reduced neuromuscular abilities that indicate an increased risk of future injuries. Moreover, special care should be given to the screening of the various impairments presented in this study among newly recruited soldiers, with an emphasis on related neuromuscular performance ability deficits, as each ankle impairment could negatively affect neuromuscular performance. Finally, identifying risk factors for future injuries should be followed up with injury-prevention programs targeted at modifying participants' deficits.[22,24,40]

CONCLUSIONS

To the best of our knowledge, we are the first to assess the prevalence of different subgroups of ankle impairments and their effect on neuromuscular performance in newly recruited combat soldiers. A high prevalence of such impairments was present in these soldiers, with differences in their neuromuscular performance deficits depending on the subgroup to which they belonged. Proprioceptive ability and triceps surae muscle strength were the main abilities that differed among the 5 subgroups of ankle impairments. Clinicians and military commanders should recognize the neuromuscular performance deficits and ankle impairments that could put soldiers at high risk for future injury. Moreover, at-risk soldiers should be provided with an intervention program before embarking on high-load training programs (such as basic training), with the goal of improving their abilities and minimizing the future risk of injury.

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