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Editorial

Research in Orienteering

Dear Reader

Although in the recent years, issues of the Scientific Journal of Orienteering became rare, research in Orienteering is not dead. But as in the international scientific competition impact factors and rating of journals became more and more important, it became more difficult to find original articles of good quality. Unfortunately, the Sci of O is not listed in these rating systems. Furthermore, as a researcher you can overlook your own field of research, but the Scientific Journal of Orienteering is an interdisciplinary journal including a variety of different areas such as mapping, education, sports sciences, medicine and many more.

These may be reasons why I was not able to find more articles for more regular issues. And realizing this, it might be a good option to hand the editorial job over to new people who can give new inputs.

This issue contains three articles. The first article reports on a psychological topic by Scott Fraser who tested anxiety parameters applying Orienteering tasks. He found that the Processing Efficiency Theory can be a good framework in order to explain performance-anxiety parameters.

The second and the third article are by my humble self. The first one reports on relationship of mechanical and functional instability of the ankle joint measured in the Swiss Orienteering National Team. We could show that athletes may perform with a very high ankle joint function although the ligaments are very unstable. This may support the fact that a good postural joint control may be trainable and may prevent from further long-term sequelae or surgeries.

The third article is an overview article on injuries in Orienteering focusing on acute ankle sprains and overuse injuries such as stress fractures and tibial shin splint syndrome. Taking care about high-level athletes and also recreational athletes needs very specialized knowledge. This article might give some insight.

At last, I hope that the life of the Scientific Journal of Orienteering will go on and that issues will be published more regular again.

And now, enjoy your reading!

André Leumann

scientific journal of orienteering

Testing the predictions of the Processing Efficiency Theory – An orienteering simulation

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Abstract

The purpose of this study was to test the key predictions of the Processing Efficiency Theory (PET) in the context of a computer based orienteering task. 15 participants were placed into either high or low trait-anxiety groups based on trait anxiety scores, and were subjected to two counterbalanced orienteering simulations: high and low pressure. Measures reflecting mental effort and efficiency of performance were taken under both conditions as well as the completion time of the orienteering task. A time-to-event paradigm was used to induce anxiety for the high-pressure simulation. As predicted, the dispositionally high trait anxious individuals reported significantly higher levels of state anxiety ($P < 0.001$) than the low trait anxious group as indexed by the self-report (MRF-L) and HR data. PET also predicts that heightened levels of anxiety stimulate an increase in on-task mental effort, significantly more so in the high trait anxious group. The findings from this study partially support PET, as participants experienced a significant increase in mental effort ($P < 0.001$) between simulations but the high trait group did not increase more than the low trait group ($P = 0.122$). Finally, PET predicts that even though processing efficiency has decreased, performance would not be necessarily negatively affected. The results revealed that the completion times between pressure simulations did not significantly differ ($P = 0.334$), providing support for PET. The findings from this study suggest that PET holds promise as a theoretical framework for providing an explanatory account of the mechanisms involved in the performance-anxiety relationship. However, a continued examination of the mechanisms that underlie changes in performance efficiency and effectiveness is needed if any concrete conclusion is to be drawn.

Introduction

The ability to cope with pressure and anxiety is an integral part of sport, especially in elite athletes (Hardy, Jones, & Gould, 1996). The influence of anxiety on the performance of motor skills has received widespread empirical attention in sport psychology research (Cerin, Szabo, Hunt, & Williams, 2000). For the purpose of this paper, anxiety will be defined as an aversive emotional and motivational state occurring in threatening circumstances (Eysenck, Derakshan, Santos, & Calvo, 2007) that has consistently been shown to impair performance (Eysenck, Payne, & Derakshan, 2005). Many theorists have argued that the negative effects of anxiety are largely due to the manner in which worry, characterized by concerns caused by evaluation of aversive situations and the threat of failure posed by these, pre-occupies attention resources of the working memory, e.g. Sarason, 1988 (as cited in Wilson, Smith, Chattington, Ford, & Marple-Horvat, D, 2006). Worry has two effects. One effect involves cognitive interference by diminishing the processing and temporary storage capacity of working memory. The second effect involves increased motivation to minimize the state anxiety, accomplished by promoting an increase in mental effort and use of auxiliary processing resources and strategies (Eysenck et al, 2007). Thus, potential performance impairments caused by the reduction of working memory resources can be compensated for.

The processing efficiency theory (PET; Eysenck & Calvo, 1992) is one theory that attempts to explain the performance-anxiety relationship and is the focus of this study. The central tenet of this theory is that cognitive anxiety, in the form of worry, impairs the processing and storage capacity of the working memory resulting in a shortage of resources available for a given task. In other words, this theory asserts that attention capacity is limited; therefore cognitions associated with high anxiety conditions consume processing resources available to the working memory, leading to a reduction in the performance of the working memory. A major difference between this theory and previous ones (e.g. Sarason, 1988) is that as well as stating that worry uses working memory resources, it is also said to stimulate an increase in mental effort. The increase in mental effort is thought to compensate for a reduction in performance effectiveness, thereby maintaining consistent, successful performance. The most important distinction in PET is between efficiency and effectiveness. Efficiency refers to the relationship between the effectiveness of performance and the effort or resources spent in achieving that performance, with efficiency decreasing as more resources are invested to attain a given performance level. In contrast, effectiveness refers to the quality of task performance indexed by standard behavioral measures (generally, response accuracy). One of the main predictions of PET is that adverse effects of anxiety on performance effectiveness are often less than those on processing efficiency.

An increase in mental effort is thought to be controlled by a self-regulatory system that is involved in managing the effects of anxiety on processing and performance (Hockey, 1986). The job of this self-regulatory system is to allocate resources where needed and is triggered by negative feedback (Baddeley, 2001) caused by the detrimental effects of cognitive anxiety. Therefore these detrimental effects of anxiety can be reduced or even eliminated as the self-regulatory system stimulates an increase in on-task mental effort, whether this is an increase in concentration or to seek external assistance. Eysenck & Calvo (1992) contend that high trait anxious individuals are more sensitive to the expected and actual performance mismatch, identified by the negative feedback loop, and are therefore more likely to be motivated to increase their on-task mental effort than their low trait anxious counterparts. Highly trait anxious individuals are more likely to appraise situations as threatening and subsequently are more susceptible to decreases in processing efficiency, so it is thought that the increase in on-task effort is more effective in this group (Eysenck, MacLeod, & Mathews, 1987). The following hypothetical example is intended to further illustrate PET; it would be expected that an orienteer going into a competitive race would experience a decrement in processing efficiency but not necessarily a decrement in performance compared to training. This decrease in processing efficiency is due to an increase in mental effort (e.g. increased concentration), which helps maintain performance.

There are some theoretical limitations to PET that are worth noting. Firstly, the assumption that anxiety impairs performance of the working memory, specifically the central executive, is imprecise as it fails to identify specific components of the central executive that are most affected. This is important as Smith & Jonides (1999) contended that the central executive is multi-functional (e.g. planning, switching attention, selecting and inhibiting attention, updating, coding representations etc). PET fails to state whether anxiety affects some or all of these functions. Another limitation is that PET does not directly explain studies in which anxious individuals might outperform non-anxious ones e.g. Byrne & Eysenck, 1995, Standish & Champion, 1960. Eysenck et al (2007) have recently developed the Attentional Control Theory, which represents a major development of the PET by catering for these identified limitations.

PET has been widely researched in various different fields. Murray & Janelle (2003) examined the central tenets of the PET in their rally driving simulation study. Their results provided convincing support for PET, as performance (course time) did not differ between baseline and competitive simulations, whereas processing efficiency decreased, due to an increase in on task effort (visual search rate). This was especially profound amongst highly trait anxious individuals ($p < 0.05$). However, a weakness to this study is that they failed to provide a comprehensive examination of how different trait anxious individuals perform motor tasks with high and low working memory demands, under varying levels of state anxiety, which would have provided this study with a more concrete conclusion. These results are consistent with previous studies supporting the PET in the same field of research (e.g. Eubank, Collins, & Smith, 2000; Williams, Vickers, & Rodrigues (2002).

Wilson et al (2006) revealed further support for PET in their rally driving simulation study. Participants were split into two groups based on dispositional trait anxiety scores. They were subsequently tested under two counterbalanced experimental conditions designed to manipulate levels of state anxiety. The results showed that an increase in state anxiety caused a decrease in processing efficiency. This was identified by an increase ($p < 0.001$) in the score of the Rating Scale of Mental Effort (RSME; Zijlstra, 1993) and a heightened level of gaze behaviour ($p < 0.05$). Predicted differences between the trait anxiety groups were also apparent, all of which offer support for PET. The theory suggests that performance effectiveness would not be necessarily negatively affected under heightened levels of competitive state anxiety, but this study revealed a significant decrease in performance (completion time; $p < 0.001$). However, a limitation to this study is that the participants had no previous experience using

the rally driving simulation. A set of participants with experience using the software would have provided a more reliable conclusion.
Williams et al (2002) tested participants in high and low working memory conditions based on complexity of shot strategy to concentric circle targets in table tennis. It is worthy to note that this is one of the few studies that have attempted to examine predictions of PET in a sporting context. Performance in both conditions was measured under high and low levels of state anxiety. Results showed that performance (target score) was better under low working memory and low state anxiety conditions and all participants reported heightened levels of mental effort, as indexed by RSME scores and visual search, in the high state anxiety condition ($p < 0.01$). Although this study revealed partial support for the predictions of the PET, several limitations were noticeable. The fact that they only used 10 participants, of whom 8 were male, weakens statistical analysis and is approaching the bare minimum in scientific research (Thomas & Nelson, 2001). The findings were nowhere near conclusive and further research is needed to determine the complex interactions between anxiety, effort and performance in ecologically valid sporting situations rather than simulations.
Research outside the sporting context has also provided some support for PET. Calvo, Eysenck, Ramos, & Jimenez (1994) conducted a study involving a reading task. Results revealed no performance differences (measured by comprehension scores) between low and high trait anxious individuals, but that high trait individuals used less efficient reading techniques (e.g. longer reading times) than their low trait counterparts. From this we can see that even though there is a reduction in performance efficiency, the performance effectiveness has not been negatively affected. However, the low number of participants used in this study does not provide a statistically strong set of results or conclusion.
In this study I will attempt to add to this body of knowledge by testing some of the main predictions of PET among participants performing a computer simulated orienteering task. I will use a time to event paradigm as a manipulation of state anxiety in the lead up to real competitive events. Through the research, I will aim to answer the following research questions in relation to PET: (1) Do highly trait anxious individuals perceive more competitive state anxiety than their lower trait counterparts, (2) does an increase in anxiety result in a higher increase in mental effort (or greater reduction of efficiency) in the high trait anxious group; and (3) despite any inefficiency in completing the task, is performance effectiveness maintained from baseline?

Based on the research discussed, it is hypothesized that:

- High trait individuals will experience more competitive state anxiety than their low trait counterparts.
- An increase in competitive state anxiety will result in a higher increase in mental effort in the high trait group.
- Despite a decrement in processing efficiency, performance will not necessarily be negatively affected.

Methods

Participants
Fifteen male national level orienteers aged 22.1 ± 2.18 years (Mean ± s), volunteered to participate in this repeated measures within-subjects design study. All participants were members of junior or senior national teams with 10.5 ± 2.47 of orienteering experience and 3.7 ± 1.16 (Max: 6, Min: 2) years training on the orienteering simulation software. None of them had corrected vision. An explanation of the general nature of the study was provided verbally and in writing and each participant provided informed consent before partaking in this study. Ethical clearance was obtained from the ethics committee.
One participant elected to withdraw from this study after the baseline measure, to ensure the simulation would not disrupt mental preparation for the actual orienteering race.

Measures
Trait Anxiety
The Sport Anxiety Scale (SAS; Smith, Smoll, & Schutz, 1990) was used to measure multidimensional sport competition trait anxiety. It consists of 21 questions, measuring reactions to competition on a 4-point likert scale (from 1= not at all to 4 = very much so). The 21 questions are divided into 3 subscales, measuring somatic anxiety (nine items), worry (seven items) and concentration disruption (five items) respectively. Adopting the approach used by Wilson et al (2006), only the cognitive anxiety subscale (worry) of the SAS was used to classify a participant as either high or low in cognitive trait anxiety. The worry subscale has been reported to have high internal consistency

and test-retest reliability (0.70; Smith et al, 1990).

State Anxiety

Competitive state anxiety was measured using the Mental Readiness Form- Likert (MRF-L; Krane, 1994). This was developed as a shorter alternative to the Competitive Sport Anxiety Inventory-2 (CSAI-2; Martens, Burton, Vealey, Bump, & Smith, 1990), more suitable for obtaining rapid anxiety measures. The MRF-L has 3; 10-point Likert scales measuring cognitive anxiety (1 = not worried to 10 = worried), somatic anxiety (1 = not tense to 10 = tense) and confidence (1 = confident to 10 = scared). For the purpose of this study, only the cognitive anxiety subscale of the MRF-L will be analysed. Validation work revealed that correlations between the MRF-L and the CSAI-2 cognitive anxiety subscales were 0.69 (Krane, 1994). This was deemed acceptable due to the need for expediency in this research and the fact that it has been used in similar studies, e.g. Smith, Bellamy, Collins, & Newell (2001) and Wilson et al (2006).

Mental Effort

The Rating Scale for Mental Effort (RSME; Zijlstra, 1993) was utilised as a unidimensional measure of mental effort, as used in Wilson et al (2006). Zijlstra (1993) proposed that the RSME score could be regarded as an adequate estimation of mental effort during the performance of a task. Zijlstra (1993) also claims the scale has robust psychometric properties after carrying out extensive validation work in a range of environments. The reliability of the scale in the laboratory (r = 0.88) and in the work settings (r = 0.78) has been globally accepted. The scale also correlates well with psycho-physiological measures of mental effort (Zijlstra, 1993), which is relevant for the secondary measure of mental effort: heart rate (HR). The RSME has a vertical axis ranging from 0 (bottom) to 150 (top). It consists of three verbal indicators: (1) 0 = 'not at all effortful', (2) 75 = 'moderately effortful' and (3) 150 = 'very effortful'. An immediate measure of mental effort is obtained by requesting the participants to mark a point on the vertical axis, reflecting the amount of effort they perceived they have invested in the task.

Gaze behaviour was recorded during each performance to give a supplementary measure of mental effort. This was measured by tallying the amount of times the participant looked at the map during each performance, identified by the amount of times the participant pressed the 'space bar'. Although this measure of processing efficiency is unique, similar techniques have been used in previous studies. Wilson et al (2006) used visual search (gaze behaviour) as a measure of processing efficiency in their rally driving simulation. It was concluded that the more time the participant visually fixated on the course, the greater the processing efficiency decrement.

A Polar heart rate (HR) monitor was used as a psycho-physiological measure of anxiety and mental effort by analysing average HR during the simulations. Wong and Kaloupek (1986) also used it to measure anxiety and it has been successfully validated against the RSME when measuring mental effort (Veltman and Gaillard, 1993). HR measurements were also used successfully to measure mental effort in Bernston, Bigger, Eckberg, Grossman, Kaufmann, & Malik (1997).

Equipment

The orienteering simulations were undertaken on the orienteering simulation software, Catching Features. Each test was done using the licensed CD-Rom on a Dell Latitude D510, 15-inch screen laptop. A Dell 2-button USB mouse was used to control movement.

The orienteering courses chosen were as similar as possible based on the IOF World Championship course standard specifications. The base measure performance was carried out using the Swiss 2003 World Championship middle distance course and the competitive measure using the Swedish 2004 World Championship middle distance course, on the orienteering simulation software; Catching Features. Each course was the same distance (5.4km), had the same number of checkpoints (22) and had the same International Orienteering Federation (IOF) level of technicality (5).

A PE 4000 Sport Tester Polar heart rate monitor was used to record heart rate during each simulation.

Procedure

Participants were requested to read and sign the informed consent form after a brief description of the study. An in-depth explanation was not given, to avoid any personal bias that a participant may have after becoming too familiar with the purpose of the study. The participants completed the SAS questionnaire prior to the base measure simulation (low pressure), and were subsequently divided into 2 trait anxiety groups, high and low. Anxiety was manipulated using a time to event paradigm in the competitive measure (high pressure). This was achieved by conducting the competitive simulation 3 hours prior to a significant national event. Immediately before both simulations the participants completed the MRF-L questionnaire and were requested to wear the Polar heart rate monitor. Immediately after the simulation they completed the RSME. The participants were requested to complete each course as fast as they could during each simulation.

Data Analysis

The mean will be used to divide the participants into high and low trait anxiety groups, as the median split is deemed inappropriate. Eight participants fell below the mean and were subsequently placed into the low trait anxious group, with the remaining seven forming the high trait anxious group

An independent samples *t*-test will be used to analyse the significance of the difference in competitive state anxiety between the trait anxiety groups in the competitive simulation. A paired samples *t*-test will be used to analyse the significance of the difference in state anxiety between the high and low-pressure simulations.

A mixed designs 2 (trait groups) x 2 (experimental conditions) ANOVA will be used to analyse the results of the RSME, MRF-L, HR and map scanning data, using the statistical package for social sciences volume 14 (SPSS). Effect sizes of the main effects will be calculated as described in Howell (1987) using control condition (low pressure) standard deviation (SD) for repeated measure effects and pooled SD for independent group effects. Significant interaction effects will be identified using the post-hoc Tukey analysis, with an alpha level set at 0.05 for a one-tailed hypothesis.

Results

State Anxiety Measures

The Independent *t*-test revealed a significant difference ($t = -4.316$, $df = 13$, $P < 0.001$) in state anxiety intensity scores between high and low trait anxiety groups in the high-pressure simulation. The high trait anxious group reported a higher level of competitive state anxiety compared to their low trait counterparts, as illustrated in Graph 1.

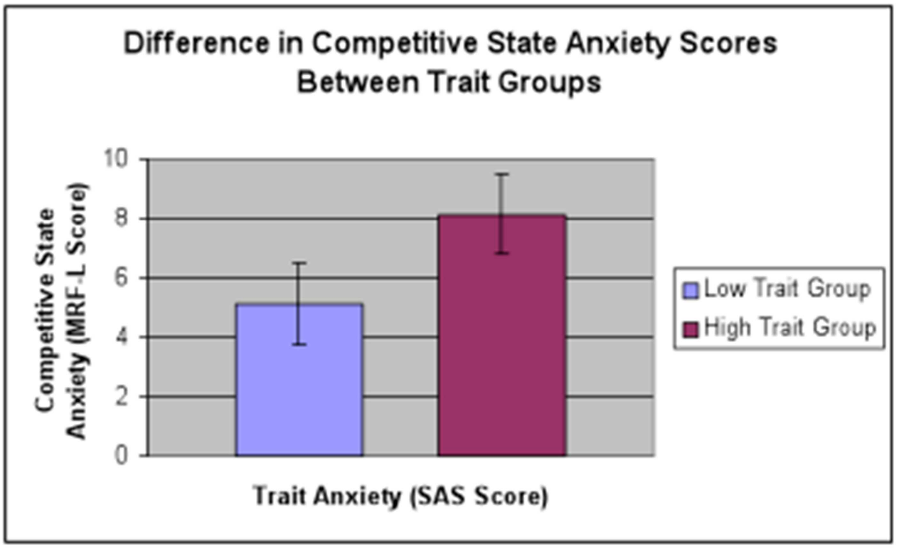
The Shapiro-Wilks (S-W) statistic revealed that both groups were normally distributed (Low anxious group: $P = 0.512$; High anxious group: $P = 0.873$).

Mental Effort

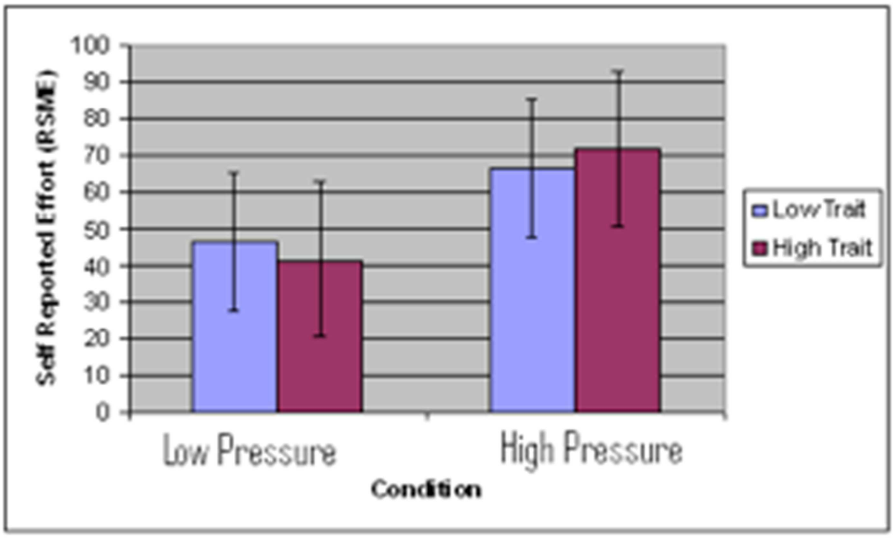
RSME. Analysis of variance revealed a significant main effect for pressure ($F_{1,13} = 71.533$, $P < 0.001$). No significant interaction effect was found for trait anxiety group X pressure ($F_{1,13} = 2.738$, $P = 0.122$). All participants reported more mental effort in the high-pressure simulation. The high and low trait groups did not significantly differ in how much they changed between the pressure-manipulated simulations. The self-reported mental effort values (RSME) for the high and low trait anxious groups in each simulation are presented in Graph 2.

Map Scanning

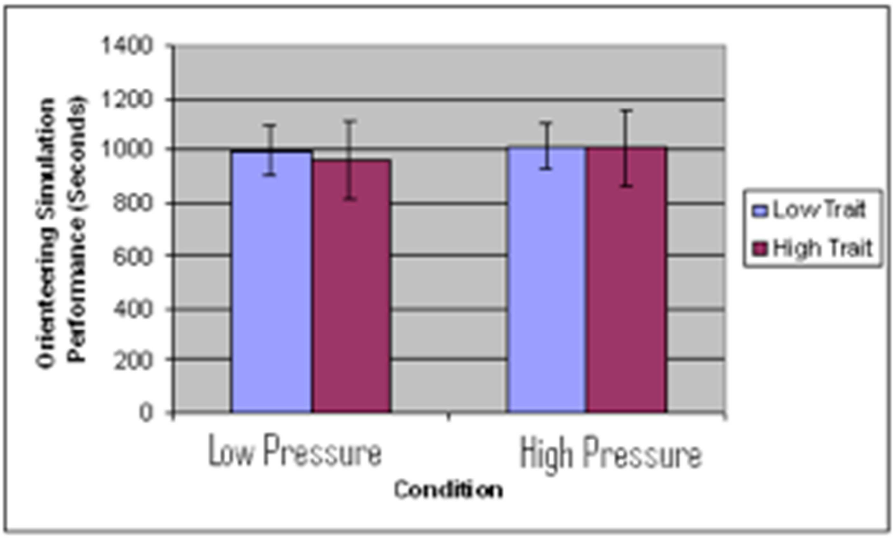
The ANOVA revealed a significant main effect for pressure ($F_{(1,13)} = 16.368$, $P < 0.001$) but no significant main effect for the trait group X pressure interaction ($F_{(1,13)} = 0.856$, $P = 0.372$). The participants looked at the map significantly more times during the high-pressure simulation and the two groups did not significantly differ in how much they changed compared to each other.



Graph 1. Competitive state anxiety as indexed by the MRF-L between high and low trait.



Graph 2. Mental effort as indexed by selfreported ratings (RSME) across pressure conditions for high and low trait anxious orienteers.



Graph 3. Timed orienteering performance across pressure conditions for high and low trait anxious orienteers.

Orienteering Performance
The ANOVA failed to reveal significant main effects for pressure, ($F_{(1,13)}$ = 1.007, P = 0.334) and the trait anxiety group X pressure interaction ($F_{(1,13)}$ = 0.186, P = 0.674). Participants' performance (completion time) did not significantly differ between simulations and neither group changed significantly more than the other. The participant's completion time data for the high and low trait anxious groups are presented in Graph 3.

Psycho-Physiological Measure
The ANOVA revealed a significant main effect for pressure ($F_{(1,13)}$ = 12.208, P = 0.004) but no significant main effect for the trait group X pressure interaction ($F_{(1,13)}$ = 0.881, P = 0.365) was found. The participants' HR increased significantly more in the high-pressure simulation compare to the low-pressure one but the two groups did not significantly differ in how much they changed.

Anxiety Manipulation
Participants recorded significantly higher cognitive anxiety intensity scores under the high-pressure simulation (69.07 ± 20.6) compared with the low-pressure (44.07 ± 20.6) simulation (t = -7.89, df = 14, P < 0.001).

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Chronic Ankle Instability
In the Swiss Orienteering National Team

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Abstract

Background: Acute ankle sprains (AAS) are the most frequent injuries in sports orthopaedics. Up to 40% of the patients with AAS develop chronic ankle instability (CAI) either as a mechanical (MAI) or functional ankle instability (FAI).
Hypotheses: Orienteering is a high-risk sport for AAS and CAI. Within CAI, MAI and FAI may appear as single or combined entity. In professional athletes, high functional ankle stability may compensate MAI.
Methods: 43 athletes of the Swiss Orienteering National Team (women, 20; men, 23) were examined clinically, and biomechanically with the Biodex Balance System (BBS).
Results: The history of AAS was documented in 37 athletes (86%). Clinical and biomechanical examination showed that 37 ankles (43%) were stable, 49 (57%) evidenced CAI. The CAI subgroups were: (A) MAI with normal functional stability, 25 (29%); (B) FAI with normal mechanical stability, 18 (21%); and (C) combination of MAI and FAI, 6 (7%).
Discussion: An orienteering athlete has high risk for AAS and the development of CAI. CAI exhibits three different subgroups: MAI alone, FAI alone, combination of MAI and FAI. In order to compensate MAI, and therefore long-term joint sequelae, specific training for improvement of functional ankle stability is advised.

Keywords: Sports, Ankle, Instability, Orienteering, Ligament

Introduction

Orienteering is an endurance sport in which athletes deal with tough terrain while performing highly cognitive orientation work. Orienteering is one of the most popular sports in Scandinavia [15,20]. Athletes suffer among other sport-specific injuries typically and frequently from acute ankle sprains (AAS) [15,20]. Despite the efficacy of non-operative treatment and physical rehabilitation management of ankle sprains [25], 10% to 30% of AAS patients may experience chronic ankle instability (CAI) [16]. Pathomechanically, CAI can be caused by *mechanical ankle instability (MAI)*, *functional ankle instability (FAI)* [3,4,9], or a *combination of both, MAI and FAI [23]*.
MAI is a ligament insufficiency mostly based on the ligamentous elongation or discontinuity. The most common MAI is the lateral ankle instability with disruption of the anterior fibulotalar ligament [7,13]; followed by a lesion of the fibulocalcanear ligament. Less often, an insufficiency of the medial hindfoot ligaments may lead to medial ankle instability [12]. In combination, lateral and medial ankle instability represent a rotational ankle instability [12]. Although for diagnostics of MAI clinical physical examination (anterior drawer test, talar tilt tests) [6], stress radiography [5], instrumented arthrometry [19], or diagnostic arthroscopy [11] have been described, only clinically physical examination and intraoperative diagnostic arthroscopy have been established for daily use.
Functional instability is described as an impairment of the neuromuscular joint stability control, which consists of three parts the afferent (e.g. proprioception, nerve-conductance velocity [25]), the central (e.g. spinal integration processes, pain inhibitors), and the efferent part (e.g. nerve-conduction velocity, strength) [9]. Often, the terms sensorimotor and postural are used synonymously to neuromuscular. Measuring all sub-factors of FAI, reported data

have been very inconsistent and objective assessment of overall FAI remained difficult.

Differentiation of MAI and FAI is important to direct adequate treatment and prevention. FAI can only be addressed by functional, sensorimotor training [25]. MAI can either be compensated by a strong neuromuscular function or treated by operative ligament reconstruction. Prevention may be done by external stabilization or sensorimotor training [25]. Although many studies have focused singly on FAI or MAI aspects of CAI, no studies tried to simultaneously address the link between both subtypes of CAI, MAI and FAI, in a high-risk athlete's cohort, as in a professional orienteering team.

Therefore, the aim of this study was to evaluate: (a) the rate of ankle sprains and CAI in a national orienteering team, (b) the distribution of the CAI subtypes, FAI, MAI, and combination of both, (c) possible athletes' coping mechanisms to overcome CAI.

Methods

In the current study athletes of the Swiss National Orienteering Senior and Junior Elite Team were examined clinically and biomechanically during their annual medical, laboratory, and sports medical check-up. The national team achieved the number one world position in the last years.

Out of 51 athletes in the National Team, 43 athletes (female, 20; male, 23; average age, 22.5 years; range, 18 to 31) participated in this study. Eight athletes could not take part due to absence (n = 6), illness (n = 1, exclusion criteria), and acute forefoot injury (n = 1; exclusion criteria). All subjects were free to participate and gave written informed consent. The study was carried out in accordance with the World Medical Association Declaration of Helsinki.

History and clinical examination

A standardized study questionnaire gave subjective information about athletes' history (Table 1). Clinical orthopaedic foot and ankle examination was achieved by an experienced orthopaedic surgeon (Table 1) and collected in a standardized study protocol. The American Orthopaedic Foot and Ankle Society (AOFAS) ankle score [17], which includes pain, function, and alignment evaluations, was used to assess overall clinical-functional level (minimum score of 0 points (minimal function); maximum score of 100 points (optimal function)).

Mechanical ankle instability measurement

Mechanical ankle instability (MAI) was documented using a grading [6] and anatomical scale (medial, lateral, or combined medial-lateral) (Table 2). The lateral and medial talar tilt stress tests as well as the anterior drawer test were performed while the athletes were in sitting position. For further statistical analysis, the instability grade of the anterior drawer test (Grade 0-3, Table 3), the lateral talar tilt test (Grade 0-3, Table 3), and the medial talar tilt test (Grade 0-3, Table 3) were added to a "Mechanical Instability Grade" (MIG) index with a range from zero (completely stable) to nine points (very unstable). A MIG index over two points was considered empirically and according to the authors' experience as pathologic. This means that an athlete with Grade 1 instability in the anterior drawer test and the lateral talar tilt test is not unstable enough to qualify for MAI classification. We were well aware of choosing a very conservative discrimination in order to minimize too many false positive (unstable) ankles.

Functional ankle instability measurement

In order to quantify biomechanically and objectively the functional ankle instability (FAI) of the athletes, the Biodex Balance System (BBS; Biodex Balance System™, Biodex Medical Systems, Shirley, New York) was used (Fig. 1).

Subjective information	Clinical examination
History of ankle sprain	Inspection
History of ankle instability	Palpation (e.g. tender points)
Giving-way and feeling of instability	Foot arch assessment
Injuries	Weight bearing hindfoot alignment
Therapies (conservative, surgical)	Range of Motion
External stabilization	Dorsi- / Plantarflexion
Training status	Inversion / Eversion
Specific foot strength training	Single heel rise test
Actual pain scale	Muscular strength test
(VAS; visual analogue scale)	Syndesmosis compression test AOFAS Ankle Score [17] Pain, Function, Alignment

Table 1. Standardized study questionnaire.

Stable	**Grade 0**	
Moderately unstable	**Grade 1**	lateral talar tilt test: opening of 10° to 15°a medial talar tilt test: opening of 10° to 15° anterior drawer test: 10 to 15 mm
Substantially unstable	**Grade 2**	lateral talar tilt test: opening of 15° to 20° medial talar tilt test: opening of 15° to 20° anterior drawer test: 15 to 20 mm
Very unstable	**Grade 3**	lateral talar tilt test: opening of >20° medial talar tilt test: opening of >20° anterior drawer test: >20 mm

Table 2. Grading of ankle joint instability.

Spring ligament	7 cases (8.0%)
Achilles tendon	6 cases (6.8%)
Anterior tibiofibular ligament	4 cases (4.5%)
Calcaneofibular ligament	3 cases (3.4%)
Sinus tarsi	3 cases (3.4%)
Posterior tibial tendon	3 cases (3.4%)
Deltoid ligament	2 cases (2.3%)
Anterior ankle joint	2 cases (2.3%)
Medial malleolus	1 case (1.1%)
Peroneal tendons	1 case (1.1%)
Other foot localisations	12 cases (13.7%)

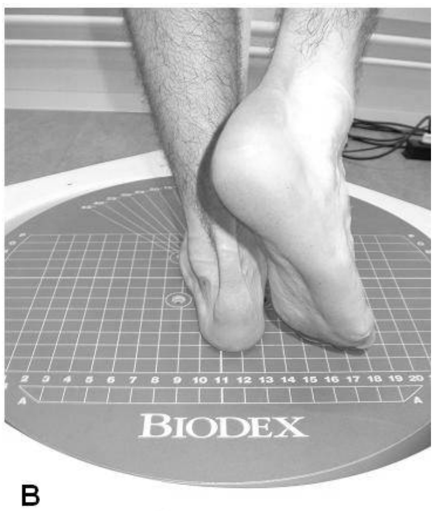
Table 3. Tender hindfoot points in Orienteering Athletes.

The BBS device measured the balance ability of the athletes on a circumferential platform by evaluating their neuromuscular potential [10]. The BBS allowed for two different assessments: static trial and dynamic trial. The task of the static assessment was to keep the platform as stable as possible in the center of balance (COB) as shown in Figure 3. As result, the static index was calculated based on the distance of the actual platform position to the center of balance for each timepoint (units, free of dimension). For the dynamic assessment athletes had to navigate the platform (COB) towards given points (Figure 3). As results, the trial time (seconds) to fulfil the task was measurend and the dynamic index was calculated based on the distance travelled between two targets in relation to the straight line distance to the target (units, free of dimension). The platform of the BBS device could be adjusted in gradually unstable levels (*moderate unstable* (BBS level VI); *unstable* (BBS level IV); *very unstable* (BBS level II) for static and dynamic trial types [22]. All tests were performed on a single-limb stance with the contralateral leg in 70°-90° knee flexion and both arms kept behind the body [22]. The center of balance was shown on a screen in front of the athlete.

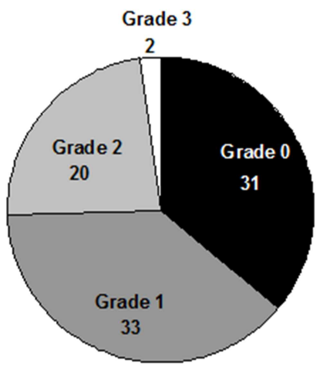
The BBS assessment protocol consisted of six consecutive trials of the left and then the right ankle with a 30 seconds rest interval between trials. The trial sequence was set in the following order: (1) static trial of 20 seconds duration (at BBS static level II); (2) dynamic trial with BBS instability level VI (moderate unstable); (3) dynamic trial with BBS instability level IV (unstable), (4) dynamic trial with BBS instability level II (highly unstable), (5) dynamic trial with BBS instability level VI (moderate unstable), (6) static trial of 20 seconds duration (at BBS static level II). The trials, which the athletes could not finish due to fatigue, were excluded for overall trial analysis. This was necessary in seven trials out of a total of 516 trials (1.3%).

For statistical analysis simplification purposes, all BBS parameters were summed to a Functional Instability Grade (FIG) index with a range from 0 (=very stable) to 20 points (=very unstable). Therefore, every test was rated specifically. Results better than two standard deviations (SD) of the average counted for 0 points, results between ± 2 SD of the average counted for 1 point, and results weaker than 2 SD of the average counted for 2 points. A value of 10 points was assigned as average, therefore a value of >11 points was considered empirically and to the authors' experience as pathologic.

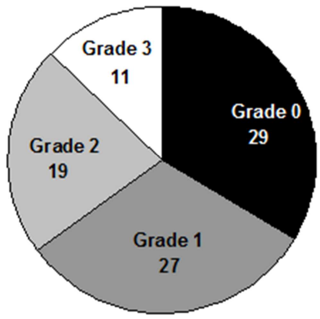
A



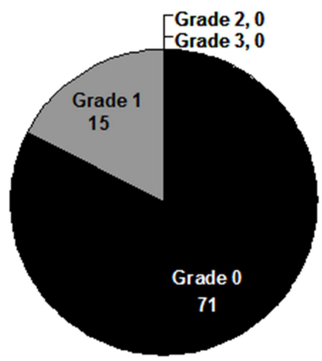
B



A
Anterior Drawer Test



B
Lateral Talar Tilt Test



C
Medial Talar Tilt Test

Statistics

Statistical analysis of the data was performed with SPSS® software (Version 12.0) to perform Student's t-test, Pearson correlation analysis (r), and multiple regression analysis. The significance level was set at alpha = 0.05.

Results

Acute sprains
A history of an acute ankle sprain (AAS) was mentioned by 37 athletes (86%). Of these 37 athletes, 31 athletes (72% of all athletes) suffered recurrent ankle sprains. In seven athletes (19%) unilateral ankle was affected, in 30 athletes (81%) bilateral ankles were affected.

Actual ankle status

At clinical examination, 16 athletes (37%) complained subjectively of current foot and ankle pain. The VAS score was in average 4.0 points (range, 1 to 10). Tenderness was found in 29 feet (34%, Table 3). The foot arch assessment showed a normal foot structure in 35 feet (41%), a flatfoot configuration in 45 feet (52%), and a pes cavus in six cases (7%). The hindfoot alignment showed in 71 cases (83%) a normal hindfoot (0°-10° eversion), in 15 cases (17%) a hindfoot valgus. No varus alignment was seen in the cohort. The average clinical-functional AOFAS ankle score was 95.2 points (range, 81 to 100 points).

Mechanical ankle instability
The results of the MAI testing are shown in figure 2. Forty-one ankles (48%) showed a combined instability in the anterior drawer and lateral talar tilt test. In 11 ankles (13%) a multidirectional rotational ankle joint instability was found. In total, a pathological MAI was seen in 36% of the ankles (31 ankles), this representing 54% of the athletes (unilateral MAI, 15 athletes; bilateral MAI, 8 athletes).

Functional ankle instability
11 athletes (26%) reported a feeling of subjective ankle joint instability.
In the functional ankle instability BBS assessment the mechanically unstable ankle group was found to perform better than the mechanically stable ankle group showing significant reduction of the static index in trial one, and of the trial time to fulfil the dynamic test in trial two and five (Figure 3).

Subgroup analysis revealed female athletes being significantly more functionally stable than males for static and dynamic trials on highly unstable platforms (level II). Whereas, Junior and Senior team members showed no significant differences between them using the MIG and FIG indices, in 58% of the cases (50 ankles) CAI (either MAI and or FAI) was seen, this represented 73% of the athletes. The comparison of the MIG and FIG index revealed four possible combinations: (A) stability in MIG and FIG: 37 ankles (43%) corresponding to 25 athletes (unilateral, 15; bilateral, 12); (B) instability in MIG, stability in FIG: 25 ankles (29%) corresponding to 17 athletes (unilateral, 9; bilateral, 8); (C) stability in MIG, instability in FIG: 18 ankles (21%) corresponding to 13 athletes (unilateral, 8; bilateral, 5); (D) instability in MIG and FIG: 6 ankles (7%) corresponding to 4 athletes (unilateral, 2; bilateral, 2) (Figure 4).

The clinical anterior drawer test showed significant correlation with the most important sub-index of the static index ($r = 0.26$, $p < 0.05$).

Neither the lateral nor the medial lateral talar tilt test showed any significant correlation to any of the functional BBS indices.

Multiple regression analysis results showed that correlation of FIG and MIG was not significant ($r = 0.005$, $p = 0.962$) as well as with the other factors AAS ($r = -0.179$, $p = 0.107$), foot arch ($r = 0.067$, $p = 0.515$) and neuromuscular training ($r = 0.196$, $p = 0.059$), whereas the correlation of FIG and amount of AAS prevention by external stabilization was significant ($r = -0.35$, $p = 0.002$) indicating that athletes that were functionally more unstable used more external stabilization aids.

Prevention and Treatment
Thirty athletes (70%) reported the use of an external ankle joint stabilization for primary or secondary injury prevention. Twenty-five athletes (58%) used taping, five athletes (12%) braces. Of them 18 athletes (42%) used the stabilization support only in competition and 12 athletes (28%) used the stabilization support in both competition and orienteering training. None of the athletes needed an external stabilization for road running. Fifteen athletes (35%) trained their lower leg muscles weekly, specifically in a force-gymnastic program for at least 10-20 minutes. Twenty-two athletes (51%) did this program on an irregular basis and five athletes (12%) never.
Twelve athletes (28%) underwent physical therapy in their athletic career due to ankle sprains. Four athletes (9%) reported a history of surgical interventions: excision of an intraarticular osteochondral fragment (n=2; 5%), lateral and medial ligament reconstruction (n=1; 2%), and open reduction and internal fixation of a lateral malleolar fracture (n=1; 2%).

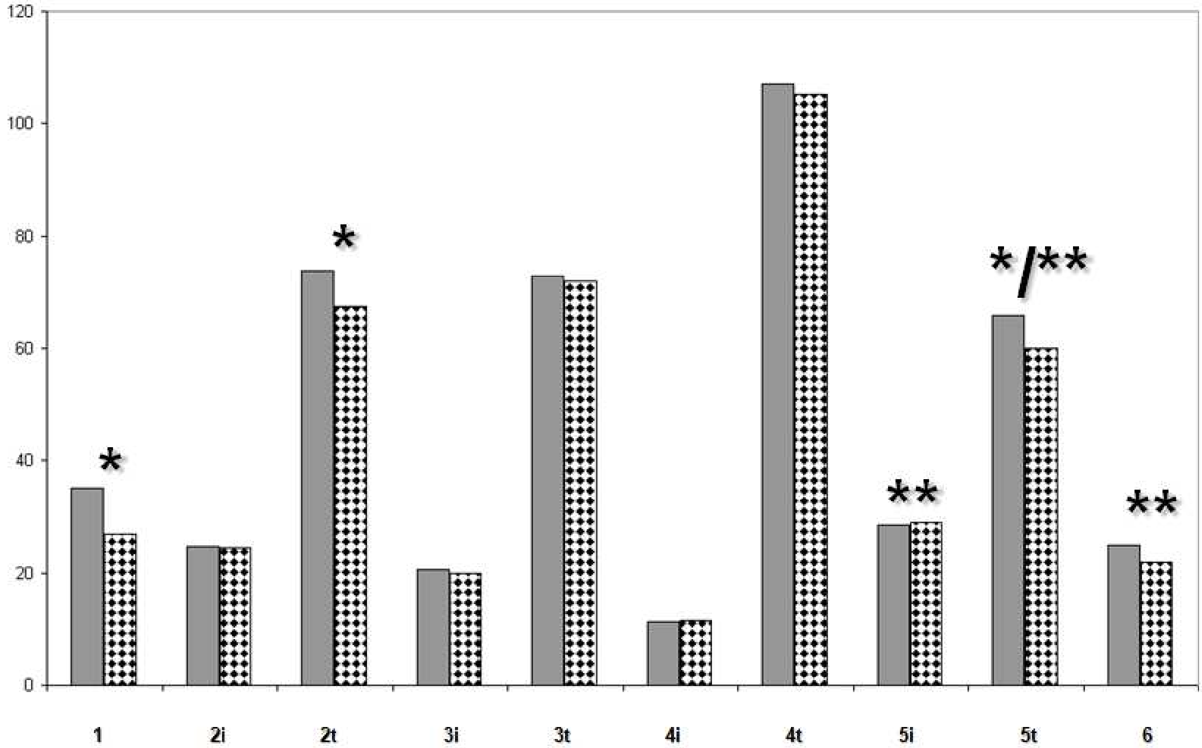


Figure 3. Results of the Biodex Stability System Assessment. Grey: group with mechanically stable ankles (n=55); Black points: group with mechanically unstable ankles (n=31). *significant difference between stable and unstable group. **significant difference from trial 1 to trial 6 or trial 2 to trial 5. Trials: (1) static trial of 20 seconds duration, (2) dynamic trial with BBS instability level VI (moderate unstable), (3) dynamic trial with BBS instability level IV (unstable), (4) dynamic trial with BBS instability level II (highly unstable), (5) dynamic trial with BBS instability level VI (moderate unstable) and (6) static trial of 20 seconds duration, instability level II (highly unstable). i=dynamic trial index (units, free of dimension), t=dynamic trial time (seconds). Results of the static trials (trial 1 and 6; static index, units, free of dimension) are multiplied by factor 10 for a better graphic understanding.

Discussion

This study provides relevant information on AAS and CAI for sports physicians, surgeons, and trainers. In the Swiss Orienteering National Team, which included 43 highly professional athletes, there was a prevalence of 86% for acute ankle sprain (AAS) (n=37). Seven athletes (16%) suffered unilateral and 30 athletes (70%) bilateral ankle sprains in their past. This proves that Orienteering has a high rate of ankle sprains and CAI and has to be considered as high-risk sport for these injuries (hypothesis a). CAI was seen in 49 ankles (57%), being either mechanical (MAI 29%), functional (FAI 21%), or both (MAI & FAI 7%). The distribution of CAI subtypes shows that every combination is possible and supports the theory that MAI and FAI have to be distinguished as two different entities (hypothesis b).

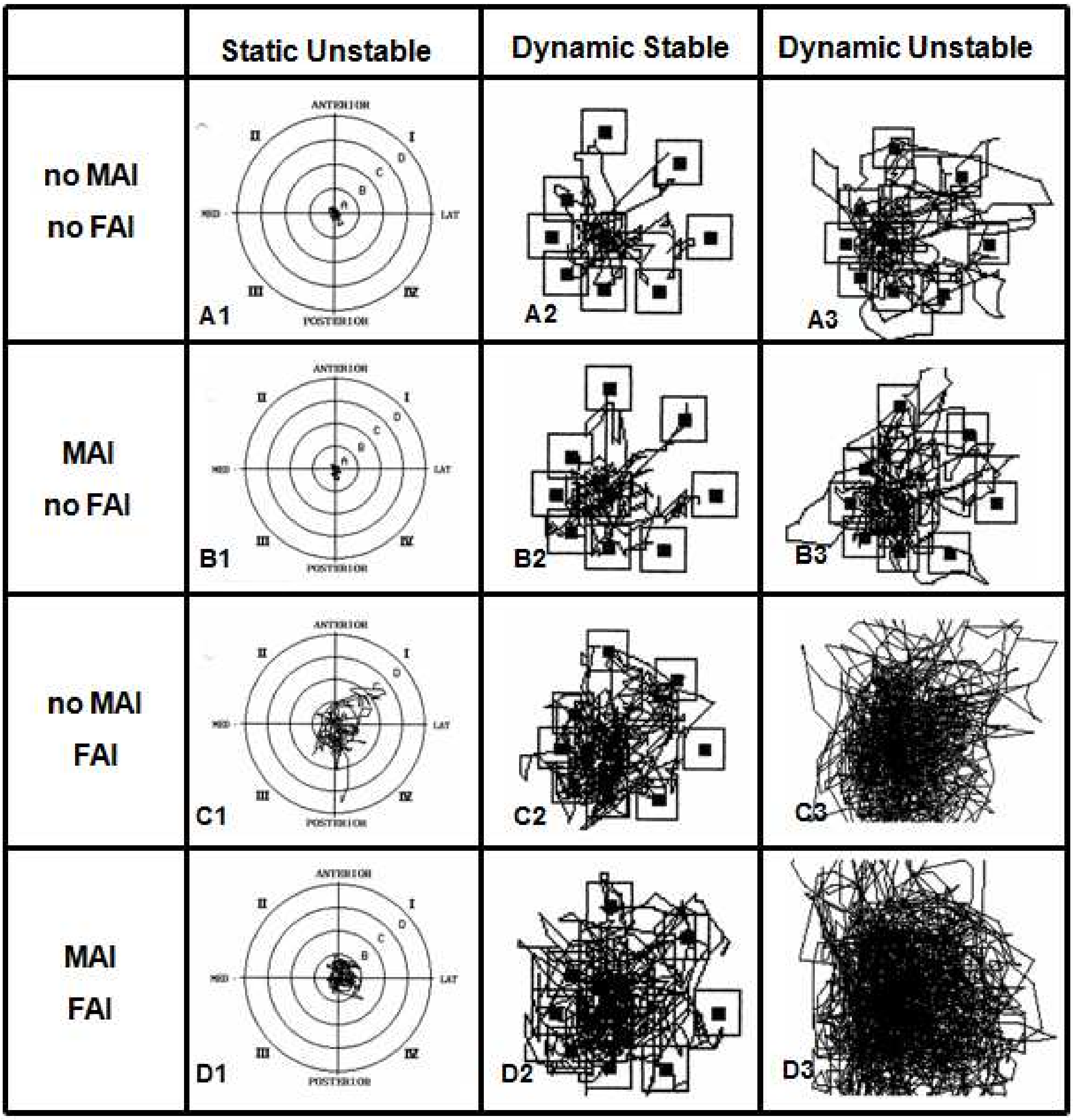


Figure 4. Stability Patterns under the Biodex Stability System. The figure shows the graphical BSS results of (A) an athlete with a mechanically and functionally stable ankle (MIG 1, FIG 6), (B) an athlete with a mechanically unstable and functionally stable ankle (MIG 6, FIG 5), (C) an athlete with a mechanically stable and functionally unstable ankle (MIG 0, FIG 19) and (D) an athlete with a mechanically and functionally unstable ankle (MIG 6, FIG 17). (1) BSS static test, (2) BSS dynamic test at level VI (moderate unstable platform) and (3) BSS dynamic test at level II (highly unstable platform).

An increased neuromuscular function seen in the majority of MAI athletes might show one possible compensation mechanism for MAI in high trained athletes (hypothesis c).

For many sports, high risks of ligamentous ankle injuries have been reported. Halasi et al. [8] recently an ankle acitivity score ranking different type of sports according to the level of competition [8]. Elite orienteering, therefore, was ranked 9 out of 10, next to soccer, handball, American football, gymnastics, basketball and rugby, which were ranked at 10 out of 10 [8]. In orienteering 13 to 58% of all injuries are AAS [15]. These data seem to be comparable to the reported injury rate of the present study, although no prevalence data for acute ankle sprains for elite orienteers has been reported in literature.

The present reported prevalence of CAI (73%) confirms the previous data of Knobloch et al. who found a rate of 60% in former elite runners [18]. No other data considering CAI in orienteering have been published yet. A possible reason for such a high CAI might be that athletes consider ankle sprains to be of “daily business” and therefore of minor relevance. 36-55% of the injured athletes don’t even seek medical advice [21]. This leads to an inappropriate treatment of AAS sprains and of CAI. Further, it is known that in normal population, the run of nonoperative treatment of an AAS implements 10-30% of CAI development [16]. As seen in this study, CAI may have a significant impact on the athletes’ performance. Athletes have pain, swelling, disturbing (37% of the athletes complained of current foot and ankle pain), subjective feeling of “giving-way” (26%), and recurrent ankle sprains which put them back from competition level. Furthermore, it has been described that CAI may lead in the long-term to posttraumatic ankle osteoarthritis and, therefore, it has to be considered as a pre-osteoarthritic condition [24].

Many authors have identified a ligamentous rupture or insufficiency as a reason for CAI. However, this mechanical ankle instability (MAI) could not explain the symptoms like a feeling of “giving-way” accurately [3]. Therefore the feeling of “giving-way” was defined as FAI, later explained as a loss in neuromuscular joint control. The history of an AAS was identified as the main risk factor for suffering recurrent ankle sprains [23]. In the meanwhile, a functional impairment was measured in many patients evidencing MAI by detecting proprioceptive deficits, muscular weakness, and prolonged reaction time [9]. Thus identifying the results as a co-incidence and therefore as one entity [14], seeing the functional impairment a symptom of the MAI [9,14].

In this study, for definition of CAI, a pathomechanical approach was chosen and the subtypes of CAI, i.e. MAI and FAI, were differentiated and measured. MAI was measured by clinically testing the ankle ligament laxity and FAI was tested by the BBS recording the neuromuscular joint control. As functional joint control is a dynamic task, measurement of functional joint stability has to be dynamic too. The BBS allowed to measure functional joint stability dynamically under a controlled, highly demanding task and to quantify joint control from a holistic perspective. However, distinction into different aspects of functional joint stability such as proprioception, muscle strength, or nerve reaction time was not possible.

In the stability testing 86 ankles were classified as follows: (A) neither MAI nor FAI, 37 ankles (42%); (B) MAI with normal functional stability, 25 (29%); (C) FAI with normal mechanical stability, 18 (21%); and (D) combination of MAI and FAI, 6 (7%). In the literature, no qualitative data are available for comparison.

Comparing the mechanical instability grade (MIG) and the functional instability grade (FIG) it was found that 25 ankles (29%) show pathologic ligamentous ankle instability but an increased neuromuscular potential. These results are contrary to the existing data [14], but are rather similar to the relation of functional stability and ligamentous instability described in the knee joint, e.g. in ACL deficient knees [1]. The fact that the anterior drawer test, but not lateral and medial talar tilt test, correlated with the functional performance may show that the functional control of mechanical sagittal plane instability may be easier to control than frontal plane instability. It was necessary to test on the highest unstable levels to detect significant differences between mechanically stable and unstable ankle groups.

These data may conclude that functional and mechanical stability or instability are different entities. Furthermore, one can assume that functional impairment may turn mechanical instability symptomatic. Whether a high functional stability (e.g. through physiotherapy training) has an effect on long-term sequelae can not be answered yet. But similar to the situation on the knee joint, it has to be assumed [26]. Valderrabano et al. showed that in ligamentous posttraumatic ankle osteoarthritis, 50% of patients revealed persistent signs of ligamentous instability [24]. In this study, mechanical and functional chronic instability did not correlate with the amount of acute sprains. This means that already one major acute sprain may be as deleterious as recurrent major sprains. Under these circumstances direct ligament repair of complete grade III ruptures in high demand athletes may be a reasonable procedure. Integrating the long-term joint degeneration but also the functional compensation potential, objective diagnostics are important to decide on treatment strategy. This study shows that the Biodex Balance System is a reasonable tool for measuring the functional stability.

It is known that prevention of ankle ligament lesion has to be addressed on three levels [24,25]. (1) Primary prevention for preventing acute ankle sprains by accurate warm-up, regular neuromuscular stabilization training and, most of all in high-risk sports like orienteering, preventive external stabilization by bracing, taping or orthosis. In this study, 30 athletes (70%) used external joint stabilization; either by taping (25 athletes, 83%) or bracing (5 athletes, 17%). A significant correlation of the use of external joint stabilization and FAI was found. (2) Secondary prevention for preventing recurrent sprains or CAI, correct treatment of an acute sprain is mandatory, consisting of rigid stabilization during the ligamentous healing and early functional rehabilitation training to regain functional stability. Recurrence of acute sprains in high-risk sports is found to be up to 80% [2]. Verhagen et al. showed in a prospective, randomized study on volleyball players that neuromuscular training may reduce recurrent sprains significantly, but not primary injuries [25]. However, it is not yet clear how much training is important to develop functional strength as found in this study. (3) Tertiary prevention is important to treat CAI correctly. New data reported a high ratio for long-term osteoarthritic joint degeneration in the ligamentous injured ankle [24]. Given a sufficient functional compensation, no data is available to know what happens after stopping with top-level training. Does functional training remain or does then mechanical instability become symptomatic and show need for operative treatment?
However, in regards to the data found in this study, it may be hypothesized that functional compensation of a MAI may be trainable and may prevent the ankle joint from long-term sequelae. Still, there is need for further, prospective long-term data. Furthermore, it is not known, to what extent this functional over-compensation is necessary. It will be important to follow-up athletes showing chronic ankle instability closely to be able to intervene if compensation is not adequate.
One of the limitations of the study was the missing radiological follow-up of the athletes' ankle. As the athletes decline ankle X-rays due to rays exposure reasons, the authors had to pass on this examination. The clinical measurement of the MAI is – beside the gold-standard of the invasive diagnostic ankle arthroscopy - in the meaning of the authors still the most appropriate way to assess mechanical instability. Dynamic stress radiography and instrumented ankle arthrometry have not yet shown a high-enough sensitivity [5,19]. MAI and FAI grading based on the authors subjective experience and lack of objective validation. The development of a grading system was necessary to address the complexity of the MAI and FAI that can only be measured with different tests. However, the limits were set in a conservative manner in order to achieve a very low number of wrong positive (pathologic) athletes. After all, BBS values that were published before were significantly weaker [22]. This shows that in functional tests, high professional athletes are not comparable to normal subjects so that it was necessary to have an intra-cohort grading as the FAI grade was. Further, it might be claimed that no matched normal population was tested. However, as this study focused on the analysis of CAI within an intra-subject high-risk orienteering cohort only, a normal population group was redundant. The athlete's population of this study shows a very high homogeneity, a high test motivation, and a high case number for studies in top level sports.

Conclusion

This study analyzed CAI in 43 athletes of the Swiss Orienteering National Team. Orienteering is found to be a high-risk sport for AAS and CAI. In CAI, FAI was not dependent on MAI. Therefore, they have to be considered as two different entities. It was found that in 29% of athletes a strong neuromuscular potential can compensate a MAI. Considering this, it may be concluded that functional stability may prevent chronic unstable ankles of long-term sequelae like ligamentous ankle osteoarthritis.
Prevention of AAS and CAI has to be outlined and addressed by the team physician and trainer. In this study, it was seen that many athletes protect themselves by regular neuromuscular training and regular external stabilization of the joint with bracing or taping. Further research is needed to elucidate FAI and its rehabilitative potential after AAS.

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Injuries in Orienteering: Ankle Instability and Overuse Injuries

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Abstract

Injuries in Orienteering most often affect the lower extremity, mainly ankle and lower leg. Two thirds of acute injuries are caused by wounds and blisters. Up to 24% of acute injuries are acute ankle sprains. Overuse injuries are more common than acute injuries. Of them, chronic ankle instability, stress fractures, and the shin splint syndrome are very frequent.

Definition of the Sport

Orienteering combines two important components: Physical endurance and the cognitive ability of reading maps. The athlete's target is to reach controls, which are positioned in a given row, as fast as possible, and this only with the help of a special map and a compass. There are official competitions in orienteering by foot, by bike, and in cross-country skiing. Three different disciplines exist in international orienteering by foot competitions: Sprint (Running time of the winner: 12-15 minutes), MiddleDistance (32-38 minutes), and LongDistance (Women: 80-90 minutes; Men: 100-120 minutes). For several years now, Switzerland is the best orienteering Nation worldwide, thanks to a good association organization, intensive promotion of younger athletes, and some exceptional talents.

Acute Injuries

According to a Finnish survey of 2189 orienteering injuries, 59,8% of the injuries happened during a competition, whereas the remaining 40.2% happened inthe trainings (Kujala et al., 1986). 73,6% of all injuries affected the lower extremity, thereof the most affected ones are the ankle (28,7%) and the knee (23,2%). Overall, 55,9 to 71% of all acute injuries are related to wounds and blisters, 1,2 to 13,2% to contusions and strains, 7,2 to 24,7% to acute ankle sprains, and 0,8 to 3,3% to fractures (Leumann et al., 2006b).

Acute Ankle Sprains and Chronic Ankle Instability

The acute ankle supination trauma is one of the most isolated injuries in orienteering. 86% of all athletes of the Swiss national orienteering team reported having had at least one or even more acute ankle sprains (Leumann et al. 2010b). Moreover, 73% of all athletes also show signs of chronic mechanical and/or chronic functional ankle instability. The most important point in preventing chronic ankle instability is the correct treatment of the acute ankle sprain. The correct treatment should include adapted immobilization depending on acuteness, external stabilization of the foot and, furthermore, a functional neuromuscular training to slowly establish stability. As written before, the frequentness of such ankle injuries is quite high. This is the reason for the athletes' trivialization of such injuries and, therefore, the treatment is often insufficient (Hintermann et Hintermann 1992).

In the pathomechanism of chronic ankle rotational instability, recurrent supination traumata lead to mechanical instability of the lateral ligaments. The anterior talofibular ligament is affected in 80% of the cases, whereas in 60% of the cases the calcaneofibular ligament is injured (Hintermann et. al 2002). Less affected is the posterior talofibular ligament, because its effect is antagonistic to the other two lateral ligaments. The lateral ligament insufficiency leads to stronger shear forces, especially the raise of rotational forces, in the talo-crural ankle joint.This results in an overload of the medial ligament apparatus (deltoid ligament) and the progressive insufficiency of the medial longitudinal arch and medial hindfoot stabilization. According to Hintermann et al. (2002), the deltoid ligament is insufficient in 40% of the patients. They complain of sprains and persistent ankle discomfort. Accompanied injuries are often seen in chronic ankle instability. In 18 to 95% of the cases, loose bodies in the joint and cartilage lesions occur. In 25 to 77% of the cases, Tenosynovitis and ruptures of the peroneal tendons are found in association to chronic instability, whereas in 9% of the cases Sinus Tarsi syndromes, and syndesmotic insufficiency appear (Leumann et. al 2010a). Long-term cartilage lesions probably lead to a high rate of osteoarthritis (Valderrabano et al. 2006). According to Knobloch et al. (1990), a higher risk for osteoarthritis was found in formerorienteering elite athletes compared to former athletic athletes.

Overuse Injury Syndromes

As also found in all the other endurance sport disciplines, for example triathlon, athletes try to exhaustthe balance of training and regeneration. Therefore it often comes to injuries caused by overuse. According to a prospective study by Johansson C (1986), 57% of the tested 89 Swedish top orienteering athletes do have injuries because of an overuse.

Stress Fractures

Orienteering athletes often show stress fractures. A retrospective study showed that in the national orienteering team 6 out of 19 female athletes (32%) suffered from a total of 8 stress fractures. If you look at the male athletes, 6 out of 23 (26%) suffered from a total of 6 fractures. The different localizations of the fractures are shown in figure 1. Most often the fractures caused by stress are located at the tibia and metatarsalia. According to Leumann et al. (2006a), those localizations are the most common ones in running disciplines. Although the awareness of the athletes rises, it is very hard to early discover stress fractures and avoid them preventively. Different extrinsic and

intrinsic risk factors have been characterized. Training, for example, is one of the extrinsic risk factors, especially fast changes in amount or intensity, or changes of the running basement. Further extrinsic factors are nutrition (e.g. eating disorders, reduced absorption of calcium, vegetarians), sports equipment (e.g. sport shoes, or the sudden change of sport shoes), drugs (e.g. Cortison, non-steroid anti-inflammatory drugs (NSAID)), and other factors like the consumption of alcohol and nicotine. Known as intrinsic risk factors are gender, age, weight, and orthopaedic mechanical factors such as foot alignment, leg length differences, bone mineral density, muscular dysbalance, and metabolic factors like the age of the first menstruation, menstruation disorders, and the history of a stress fracture in the past. The treatment of stress fractures needs a high patient compliance and a close guidance by a sports physician. The sports physicians' function is to prevent a tooearly enhancement of the training. The therapy follows primarily the criteria described by Fredericson (1995). However, high risk fractures (tibia, medial malleolus, naviculare, sesamoide, and metatarsale V) show up a longer rehabilitation time and the risk of a pseudarthrosis (Leumann et al. 2006a).

Localization	*Frequency (in %)*
Tibia	46%
Metatarsalia	27%
Fibula	8%
Pelvis ring	8%
Navicular	3%
Others	8%

Table 1: Localizations of stress fractures (in %). 29% of all the athletes already suffered from fractures caused by stress.

Shin Splint Syndrome

Lots of athletes suffer from the shin splint syndrome. It often appears during spring, when the athletes change their training from basic endurance training to specifically competitive Orienteering training. Thereby the intensity of the training sessions increases. In orienteering, the focus during spring and summer is on orienteering and technicalabilities, whereby the athletes more often train off road in comparison to the winter training (Züst et al. 2009). Therefore, a remarkable change of the training conditions takes place. This also requires a change in running shoes. Special orienteering shoes are less damped and have deeper profiles than normal running shoes, so the stand on a softer ground is better (Fig. 1).

Typically, injuries are located on the medial side of the tibia, where exquisite pressure points can be found. In the early stage, the athletes feel the pain at every beginning of a training session. After the warm-up, the symptoms usually disappear, but most often at the end of the training the pain comes back. In the advanced stage of an injury a swellinggets visible (Fig. 2). If an athlete has reached this advanced stage, the symptoms will not disappear during the training, furthermore, they probably will show up when normally walking, or even during rest periods. Athletes, who usually run on the forefoot, are more frequently affected and it is not rare that both feet are hit by the injury at the same time (Leumann et al. 2006a).

In many patients a flatfoot is found. Out of all athletes of the Swiss National Team in Orienteering, 52% feature a flatfoot (Leumann et al. 2010b), whereas among hobby runners the quote is just 35% (Hohmann et al. 2003). Assumably, a flattening of the medial longitudinal arch of the foot leads in orienteering, as well as in other sports (e.g. gymnastics), to a better dynamic foot stability. Due to this flatfoot position, an additional force on the posterior tibial tendon is produced. A biomechanical study byUchiyama et al. (2007) describes a 40% higher sliding resistance.

In differential diagnostics, the difference to a compartment syndrome or a tibial stress fracture is quite hard (Züst et al. 2009), especially because it is possible that a shin splint syndrome may results in a tibial stress fracture. Thus, a magnetic resonance imaging can help in such a case for differentiation. The therapeutic treatment uses local NSAID applications, such as Flector patches (IBSA pharmaceuticals, …), or physical methods (ultrasound, ice, muscle relaxation). In addition, an orthopaedic, insolecombined with a brace support of the hindfoot and, besides, muscular training of the lower leg muscles, so the athlete is able to adjust and to stabilize the hindfoot. Finally, an adaption of the training or even a break is useful and it is the only way to breach the chronic process of inflammation.

Figure 1. *Orienteering Shoes.* Orienteering shoes show are less damped than normal running shoes for having a better proprioceptive input. The profile is deep; therefore the athletes have a better stand on soft ground. On the bottom side, small metal spikes provide a better hold on wet wood or stony plates.

Figure 2. *Shin Splint Syndrome.* This figure shows a 25-year-old female athlete with a shin splint syndrome at her left lower leg. The swelling above her medial tibia brink is clearly visible and abolishes the silhouette above her left inside ankle, if you compare her right with her left leg.

Conclusion

Generally, orienteering is a sport with a low injury incidence. When looking at acute injuries, acute ankle sprains come to the fore and when attention is given to chronic discomfort, then the chronic ankle instability outweighs. In cases of competitive sports, it is important to have a look at injuries based on capacity overload, for example the shin splint syndrome, as well as stress fractures. When having ankle sprains or injuries based on capacity overload, preventive methods and adapted immobilization depending on acuteness are the central points to look at.

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