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EDITORIAL

Many contributions in former issues of the Scientific Journal of Orienteering dealt with the question how orienteers, by help of a map, find their way in unknown terrain. The way how people navigate, however, is an interesting research field not only in orienteering. Whitaker and Cuqlock-Knopp (p. 55) have by means of interviews identified strategies of navigation in orienteers and military scouts. The results presented indicate that off-road navigation seems to have, independent of the context, common strategical aspects.

Injuries, whenever they occur, are unpleasant moments in an orienteer's life. Several studies, some of them published in the Scientific Journal of Orienteering, showed that orienteering is not a particularly dangerous sport. Hintermann and Hintermann (p. 72) have confirmed this finding also for Middle European alpine terrain, with ankle sprains and cuts being the most common injuries. In a second article, the same authors go more into details regarding ankle sprains (p. 79). Adequate treatment of lateral ankle ligament injuries is considered to be of high importance for both future stability of the joint and prevention of overuse injuries.

Call for papers: The Scientific Journal of Orienteering lives from good contributions on orienteering research, applied studies or reports on practical experience. With this call for papers I would like to encourage everyone who is somehow engaged in orienteering to submit contributions for consideration for possible publication. The comments on the papers by members of the Editorial Board after the reviewing procedure may also help the author(s) to improve the scientific qualification and to get into contact with other persons interested in the fieldl. Comments on previously published articles are also highly welcome in order to stimulate the exchange between research and applied work.

R.S.
NAVIGATION IN OFF-ROAD ENVIRONMENTS:
ORIENTEERING INTERVIEWS

Leslie A. Whitaker and Grayson Cuqlock-Knopp

Abstract

Navigation in off-road environments requires the use of different environmental cues and cognitive models than does navigation in human built environments. Cues, strategies, and skills are critical elements in the successful navigation of off-road terrain. To examine the importance of visual cues and their use in problem-solving strategies and navigational skills, sixteen interviews were conducted with orienteers and military scouts using a semi-structured interview technique known as the Critical Incident Technique. The analysis of these verbal protocols produced a taxonomy of the navigator’s cognitive models. This taxonomy was cross-validated in a split-half analysis of the interview data.

Introduction

Navigation is a task executed with more or less skill by many people in a variety of environments. These environments can be categorized in various ways; one of these ways is the distinction between human constructed (built) environments and natural ones.

Much has been published describing the ways in which people navigate within the built environments of our modern communities. Wickens (1984) reviewed the psychological literature on space perception, maps, and navigation. Thorndyke (1980; Thorndyke & Hayes-Roth, 1982) has described the process of learning to navigate in a new area. Many authors have explored the issue of cognitive maps. Tolman (1948) coined the term in an effort to explain that environmental information is remembered and used in the context of the person’s (or rat’s) total concept of the environmental area. Others have explored the
development and use of cognitive maps and cognitive models (Aretz & Wickens, 1990; Cadwallader, 1979; Evans & Pezdek, 1980; Evans et al., 1984; Foley & Cohen, 1984; Goldin & Thorndyke, 1982; Goucelis, Golledge, Gale, & Tobler, 1987; Harvey, 1980; Kozlowski & Bryant, 1977; Leiser, 1987; McNamara, 1986; Rossano & Warren, 1989a, 1989b; Sholl, 1987; Wickens, 1990). This is not an exhaustive list of the publications which have explored the issues of cognitive models and their influence on navigation. Further work has been done by cartographers or developers of maps and map aids in attempts to clarify the ways in which navigators use maps and map aids as navigational tools (e.g., Blades & Spencer, 1987; Boys, 1986; Hunt, 1984; Monmonier, 1991; Salichtchev, 1978; Streeter, Vitello, & Wonsiewicz, 1985).

Considerable attention has given to the ways by which humans navigate in built environments. Far less has been published which describes the cognitive models of people navigating on the ground in natural settings. However, the scientific study of orienteering has yielded interesting research on this topic. Seiler (1985, 1989) studied the information processing and decision making used by skilled Swiss orienteers. He analyzed the route planning and choice decisions of these orienteers in both laboratory and field tasks. Two specific strategies were employed by these experts: reduction of physical or technical expense and maximizing the effect of a selected route. While both strategies were called out in the laboratory study, the former (reducing expense) was more often employed in the actual field test. Murakoshi (1986, 1988, 1989, 1990) has examined the cognitive aspects of orienteering as an information processing task, both in its planning and in its execution. His information processing model (Murakoshi, 1986) emphasizes that the orienteer must match internal representations of the route (an integrated schema of the task) with the external cues being selected from the environment. He alludes to the difficult problem of making errors by misinterpreting the environmental cues to match the internally held schema. This error is more likely to occur when the environmental cues are ambiguous, and natural environments (with their dearth of symbolic or manmade features) do contain numerous ambiguous terrain features. Off-road navigational experience does improve the ways in which navigators can extract reliable information from natural features. Murakoshi (1988) used data obtained during photo-orienteering in an attempt to determine how experts and novices extract information from the environment. The results were not totally clearcut, but it was found that experts could use additional viewing time (extraction time) to improve the accuracy of their responses, whereas additional viewing
time was not helpful to novices. Murakoshi's photo-orienteering subjects were attempting to solve a relocation problem which required that they determine their location by matching the features in the photograph with the topographic map of the area. Thompson et al. (1990) studied a similar task in which subjects were blindfolded and physically taken to a location. The subject must then determine where his/her present location was on a map. They have called this "the drop-off problem." Their theoretical paper describes several strategies which people can employ to determine their current location under these circumstances. Finally, Murakoshi (1989) describes the importance of errors in the process of executing a navigational task. He emphasizes that humans make travel plans, whether in built or in natural environments. However, during the execution of these plans, errors or changes occur. The skill of navigation often hinges as much on the ability to recognize and recover from an error as on the initial skillful planning of the route. There is a need to know more about both navigation in natural settings and about the navigational aids which might be helpful in supporting those tasks. The present research was conducted to explore these issues further and to develop a model of the off-road navigator's cues, strategies, and skills.

There is a priori reason to be cautious about attempting to generalize research results from built environments to natural ones. The two environments (built vs. natural settings) differ in several important dimensions. A few of these dimensions can be used to illustrate this point:

1. Built environments make extensive use of straight lines and square corners. Fletcher (1965) noted that square corners are so rare in natural settings that he was able to use that feature as a distinguishing clue for recognizing the archeological remnants of Anasazi settlements in remote areas of the Grand Canyon.

2. Built environments in developed nations make extensive use of signing and linguistic cues. Streets are signed; maps use names of features and these names will actually be found in the environment. One of the authors was successful traveling in Moscow recently by using a street map and handlettered labels bearing the names of subway lines and stops, despite the fact that she knew very little of the Slavic alphabet or the Russian language. She traveled by matching the symbolic (in this case, a set of letters defining a word) information from her map aids to the same symbolic information displayed in the real world. This type of navigation is not possible in a natural setting because the label, for
example, Mt. Shasta, on the map is not displayed in neon letters across the actual mountain.

3. Built environments allow movement by foot or in a motorized vehicle, while natural settings generally preclude the use of any means of locomotion except human or animal power. The exception to this generalization is the use of all-terrain vehicles or the modern military "jeep" called a HUMMER. Even using such off-road vehicles, distance is covered much more slowly in natural settings than in built environments. The type of information which can be obtained from the built and the natural environments often differs because of this difference in rate of movement.

The present study was designed to explore navigation in natural environments. Natural environments are not necessarily devoid of manmade objects. They may contain trails, fences, ditches, an occasional building (horse corral, foundation, lean to). However, they generally do not contain settlements, signed pathways, or roads. We have labeled navigation in these natural environments as "off-road navigation."

The focus of the study was on the psychological processes employed to conduct this task. Broadly, these can be divided into three categories: perception, decision making, and response selection. The goal of this study was to develop a taxonomy which described the content of the off-road navigator's cognitive model in these three categories. We defined the categories of this taxonomy as follows:

1. Cues. The sensory information which the navigator selects from the environment is used to form perceptual units upon which the subsequent stages of the task can build.

2. Strategies. The decision making processes used by the navigator operate upon the cue information given. Furthermore, they direct the search for further cues from that environment or dictate the need to anticipate the occurrence of specified cues at a later point in the task.

3. Skills. The selection of an appropriate response choice requires that specific skills be employed to use the cues and the decision-making strategies.

Orienteers and military scouts were selected to participate in this study as subject-matter experts. Both groups of navigators travel by foot using map and compass to select routes across country, often eschewing even foot trails. To be successful, their tasks require spatial skills, map
and compass skills, accurate interpretation of their environment, and rapid decision making. These cognitive aspects of the off-road navigation task were our focus. These navigators were interviewed; the verbal protocols from these interviews were then coded to obtain navigational cues, strategies, and skills.

Methods

Knowledge Acquisition

Sixteen interviews were conducted with civilian orienteers and military scouts as subject matter experts (SMEs). The majority of our subjects (12) were civilian orienteers. Orienteers and military scouts perform a similar navigation task, although the former does so for pleasure, while the latter is doing so at work. Our goal was to determine what navigation skills are necessary for successful completion of this task; what strategies are employed by the navigators; and which visual cues are observed from map, compass, and environment to execute those strategies successfully.

Many well-developed skills (especially those involving non-verbal material such as visual pattern recognition) are difficult for an expert to describe. In the present interviews, we used a technique, known as the Critical Incident Technique, which has been employed successfully to elicit such information (e.g., Crandall, 1989). Each navigator described a specific navigation incident in which his or her skill had been needed to navigate successfully. These incidents ranged from a trek across Polar Bear habitat in northern Canada to a timed course through wooded parkland in the midwestern United States. Probe questions were then used to elicit visual cues, strategies, and skills used by these off-road navigators to solve their navigation problems during that incident. Each interview required approximately 1 1/2 hours to complete. For 14 interviews, the subjects brought the maps they had used during the navigation task itself. (Two interviewees did not have maps of their specific terrain: one military scout described the task of finding an exact location for a radio antenna and another described a night patrol in a training exercise. Each man had a map of similar terrain which he used to illustrate his points during the interviews.) Two examples of interview probes are found in Table 1.
Table 1. Probing during an interview. "Bob" is the orienteer's code name in this interview. "Leslie" is the interviewer. Probe 1 yields a prediction strategy. Probe 2 yields a series of visual cues.

Example Probe 1.

Bob: In this particular map there are a lot of things that [are] in your mind. You are out there running and trying to do things quickly. You can mistake every depression you see. So if you think you are in one, you better check it.

(Probe)
Leslie: How do you check it?
Bob: You predict where the next feature is that you want to go to. In this case, it is another small depression. A lot of people get hopeful when they are out there and won't be realistic.

Example Probe 2.

Bob: This terrain is kind of tough for doing what I call "looking away/across" for another feature, perhaps a hilltop.

(Probe)
Leslie: Under what circumstances would you want to look away if the terrain allowed it?
Bob: Coming down a hillside where you are looking for a dry ditch or small reentrant and there is a number of them to choose from. If you notice across the stream a particular feature there may be a saddle or a hilltop, or there might be another large reentrant coming in right across from the one that you want.

Taxonomy Development

As with any knowledge elicitation task, the interviewer should have as much prior knowledge as possible of the domain. In this case, the interviewer is a cross-country hiker, skilled in the use of topographic maps and compass. She has participated in orienteering meets. Prior to conducting these interviews, she read orienteering books and articles. She discussed the strategy of the project with orienteers. However,
these sources were not sufficient to establish the exact coding procedure to be used for these interviews. Instead, a coding procedure was developed by using a subset of the interviews themselves.

To accomplish this coding, audio tapes of the interviews were made and subsequently transcribed for analysis. The verbal protocols were analyzed in a split-half coding procedure: a randomly selected eight interviews were coded to determine the types of visual cues and strategies used.

**Cross-Validation**

These categories were then used to code the remaining eight interviews. This method was used to determine whether the coding categories which had been tailored to match one-half of the data would be good descriptors of the remaining interviews. The cross-validation was excellent. To obtain an indication of the statistical significance of the differences among frequencies in categories, a Wilcoxon Sign Test for differences between related samples was conducted for the 10 pairings of the cue categories, 6 pairings of strategy categories, and 6 pairings of skill categories (Snedicor & Cochran, 1980). These tests were conducted separately for each sample half to determine the reliability of the rank ordering within the sample half. The cross-validation consisted of the comparisons between the findings for the two sample halves.

The cue and strategy categories were in close agreement for the two sample halves (see Tables 2 and 4), both in the use of the same categories and in the frequency of their mention. The same four skill categories were used by both sample halves; however, the frequency of their occurrence differed between the two sample halves (see Table 5).

**Visual Cues.** The same five categories of visual cues were used by both halves of the sample. Total number of cues uttered varied widely among interviewees; therefore, frequencies were converted to proportions and this was the datum used in the non-parametric analysis of significance. The mean proportions are tailed by cue category and sample half in Table 2. The rank order of mention was the same for both sample halves: manmade > land contours > water features = vegetation > other. The Wilcoxon Sign Test (for the differences between two related samples), was used to determine the significance of the differences. When \( n' = 8 \), the critical value of \( p < .05 \) is 4. Using this criterion, both sample halves used manmade cues significantly more frequently than the remaining categories, and contours more than the "other" category.
Table 2. Mean Proportions of Environmental Cues.

<table>
<thead>
<tr>
<th>Cue</th>
<th>First Half</th>
<th>Second Half</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manmade</td>
<td>.35</td>
<td>.30</td>
</tr>
<tr>
<td>Contour</td>
<td>.24</td>
<td>.28</td>
</tr>
<tr>
<td>Water</td>
<td>.16</td>
<td>.18</td>
</tr>
<tr>
<td>Vegetation</td>
<td>.15</td>
<td>.18</td>
</tr>
<tr>
<td>Other</td>
<td>.10</td>
<td>.07</td>
</tr>
</tbody>
</table>

Problem-Solving Strategies. In addition to coding the visual cues, the strategies used by the navigators in employing these cues were coded. Four strategies were coded from the first half of the sample: prediction; recovery; use of catching features; and aiming off. Descriptions of these strategies are as follows:

1. Catching features serve to guard the navigators from going too far beyond their goal location. "It's a big stream. If I keep going north, I am going to hit it." is an example of using a stream as a catching feature.

2. Aiming off is the strategy of deliberately planning a route which will not bring the navigator to the exact goal location. It is usually used in combination with a linear feature, like a river or a road, which will mark the navigator's general location near the goal. For example, "I would aim off slightly to the right of north. Last thing that I want to do is miss the stream crossing [a ford]." If this orienteer had planned a route directly north and he had not seen the ford when he reached the stream, he would not have known whether to run east or west to actually reach it.

3. Prediction can be used under two general circumstances: to check the accuracy of route finding or to test a location hypothesis. Good orienteers explained that they anticipate various route features as they follow a route. They use terms like "predict", "anticipate", and "should be" to describe this process. By using their maps to find various features further along their intended route, they are able to anticipate their appearance. Using this prediction method, they are quickly able to determine if they have strayed from their intended route. When a navigator questions whether he or she is in
the correct location, prediction is used to determine which features should be visible from the hypothesized location.

4. If the navigator does lose his/her way, some means of recovering the route (or location) must be used. These navigators reported that they seldom blindly continue through the countryside, hoping to see some feature that will orient them. Some of our orienteers physically retraced their steps to their last known position. Alternatively, they might mentally retrace their actions to develop a hypothesis of where they currently were. Finally, they might engage in feature prediction to determine what position on the map would afford a view of the features presently visible: "I knew I was lost; it was time to start from scratch—which is basically, get the map out, line it up, turn around, look and see where am I. Where can I identify a landmark?"

The mean proportions are tabled by strategy category and sample half in Table 3. The rank order of mention was the same for both sample halves: Prediction > Recovery > Catching Feature > Aiming Off. The significant differences found for both sample halves were that Prediction and Recovery were used significantly more often than Aiming Off. The four strategies coded in the first sample-half applied to 94% of the strategies used by the second half of the sample. The remaining 6% consisted of strategies to employ stealth (either for a competitive edge in orienteering or for protection in scouting) and speed (one young orienteer relied upon his strength and speed to excel in competition).

Table 3. Mean Proportions of Problem-solving Strategies.

<table>
<thead>
<tr>
<th>Strategy</th>
<th>First Half</th>
<th>Second Half</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prediction</td>
<td>.45</td>
<td>.42</td>
</tr>
<tr>
<td>Recovery</td>
<td>.27</td>
<td>.38</td>
</tr>
<tr>
<td>Catching Feature</td>
<td>.19</td>
<td>.14</td>
</tr>
<tr>
<td>Aiming Off</td>
<td>.08</td>
<td>.06</td>
</tr>
</tbody>
</table>

Navigation Skills. Navigation requires several separate skills, each of which must be accomplished as an interaction involving the navigator's problem solving strategies and the cues available in the environment. The skills required for successful navigation can be classified in four
categories: Route Choice, Route Finding, Location, and Orientation. These four skills are described below.

1. Route Choice, the strategic activity of selecting a route, depends upon the navigator's knowledge of the terrain to be traveled, the ease of movement, and speed with which he or she can cover that terrain (Selwyn, 1987; Murakoshi, 1990). Seiler (1985) studied the performance of elite Swiss orienteers. He stated that orienteers evaluate a longer and easier route for a shorter, but steeper one. In the present study, we interviewed orienteers with much less experience and found that they reported the same trade offs described by Seiler's more experienced subjects. One orienteer reported that he asked himself: "Do I run longer around the road or take a more direct route, but with more elevation change?" Another offered as a rule-of-thumb: "You can climb 1 ft. in elevation as quickly as you can run 10 ft. horizontally." Furthermore, experienced navigators consider the possibility of becoming lost when selecting among various routes. For example, the security of staying on a trail vs. moving across country would be considered in choosing between routes.

2. Route Finding describes the actual process of finding or following the chosen route. Wickens (1984) reviewed three ways in which people manage this task. Prominent landmarks may be used as markers of the line of travel. A more detailed use of landmarks occurs when the person strings together a series of landmarks or visual features to designate a route; this information is known as route knowledge. Finally, a person may learn enough about an environment to follow a new route between a start and a goal position; the cognitive map necessary to follow this route is known as survey knowledge. Thorndyke (1981) has proposed that people moving through manmade environments (e.g., cities) change their use of route finding knowledge. As knowledge of the specific geographic area increases, the traveler graduates from landmark to route to survey knowledge. We have found no published literature addressing this question in off-road environments. However, the use of known landmarks may be comparable to the use of individual prominent terrain or mapped features in off-road navigation. This hypothesis is open to question since the use of landmarks in built environments assumes that the landmarks are previously known, while competitive orienteers are often unfamiliar with the specific area used in the meet.
3. Thompson et al. (1990) defined the location skill as the "process of establishing a match between particular locations in the environment and the corresponding locations on a map." These authors provided strategies for localization problems in off-road environments. They suggested that localization problems range from drop off (determining where you are) to route finding itself. This is consistent with the results obtained in the present study. Knowledge of one's present position is related to route finding. The navigator must know where he or she is located in order to complete a chosen route successfully. Orienteers described this as an important skill: "The single most important thing in orienteering is knowing where you are in the first place." The requirement of knowing one's position can be relaxed under certain circumstances: "You can use something high as a prominent landmark. Then you don't have to know where you are all the time." "If I don't know where I am, it doesn't really matter. If I just keep going north, I am going to hit the catching feature." One skill ascribed to expert orienteers is the ability to obtain location knowledge quickly and accurately: "The expert orienteers just look around; as they pass something, they look on their map and check it off."

4. Orientation refers to the ability to know the compass directions from one's current position. People skilled in orientation know which way they are facing and where (compass declination) a visible landmark is from that current position. Many of the navigational research projects reported (e.g., Evans & Pezdek, 1980; Chase & Chi, 1980; Rossano & Warren, 1989a, 1989b) describe errors in orientation skill. Rossano and Warren's results were particularly interesting because they showed that both blind and sighted subjects made similar errors in encoding directions from a map. (Again, these studies asked subjects to navigate in a built environment—not an off-road environment.)

The mean proportions are tabulated by skill category and sample half in Table 4. Although the same four skills were described by the interviewees, the rank order of mention was not the same for both sample halves. The significant differences found for the first sample half was that Location > Route Finding. For the second sample half, Route Choice occurred significantly more frequently than Route Finding.
Table 4. Mean Proportions of Navigational Skill Categories.

<table>
<thead>
<tr>
<th>Skill</th>
<th>First Half</th>
<th>Second Half</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>.29</td>
<td>.21</td>
</tr>
<tr>
<td>Route Choice</td>
<td>.28</td>
<td>.34</td>
</tr>
<tr>
<td>Orientation</td>
<td>.26</td>
<td>.25</td>
</tr>
<tr>
<td>Route Finding</td>
<td>.16</td>
<td>.20</td>
</tr>
</tbody>
</table>

Discussion

The major goal of this study was to investigate the cues, strategies, and skills employed by off-road navigators. This was accomplished by interviewing subject-matter experts in the area. Analysis of these interviews yielded a taxonomy for the three categories of interest. This taxonomy was developed and was found to be consistent in a cross-validation between sample halves. The categories are consistent with those which have previously been described as critical orienteering strategies and skills (e.g., Martland, 1983; Seiler, 1985, 1989; Thompson et al., 1990); however, the frequency of mention for these categories is of interest because of their consistency across a wide range of off-road navigation tasks. The navigation tasks used in the development of this taxonomy were bounded only by the initial probe to describe a navigation task in which the interviewee’s navigational skills were challenged. The task terrain varied from polar tundra to Ohio hill country to Scottish glacial till. The task goals ranged from novice orienteering (primarily on trail navigating) to expert national competitions to military surveillance operations. Given the variety of off-road navigation tasks described by these interviewees, there is an impressive level of communality in the categories employed, as well as the frequency with which each category was mentioned. Several interesting points are illustrated by this taxonomy which confirmed the expectation that the cognitive model of off-road navigation would differ in some aspects from navigation in built environments. The most frequently mentioned cue category was manmade cues: a house; a fence; a ditch. These cues are important in off-road navigation because they are unique. A different class of cues would be important in a built environment. The book "A Tree Grows in Brooklyn" illustrates how important a unique cue can be. This uniqueness is dictated by the surrounding environment. "A Tree Grows in the Rain Forest" is not yet
a unique object, and hence would not be a noteworthy visual cue to route, bearing, or location.

While no quantitative evaluation of the sequential links between cues and strategies was undertaken, some relationships were of interest. Since our ultimate goal is the development of a decision aid, we were interested in determining the circumstances under which particular visual cues would be used to populate the navigation strategies employed. Some generalities can be stated at this point; however, these await confirmation in the development of the decision aid prototype. Two simple examples (more appropriate to the level of novice off-road navigation) will suffice to illustrate these linkages.

1. Linear features are most commonly used with the strategy of Catching Features. A linear feature may be a Manmade feature (a road or a trail); it may be a Water feature (a stream, river, or lake); it may be a Contour feature (a cliff); or it may be a Vegetation feature (edge of a field).

2. The search for a point feature most often promotes the use of an Aiming Off strategy. This point feature may be any one of the visual cue types. It may require the search for a manmade control; the intersection of a road and a trail; the location of a bridge or a ford. Each of these features is a point feature. When a point feature is difficult to see from the navigator's current position, he (she) may use Aiming Off to avoid missing it.

The reliability of the taxonomic categories and (in general) of their frequency of occurrences has encouraged us to begin to make use of this taxonomy in the development of a prototype of a computerized navigational aid. The user interface is being programmed in Hypercard 1.2.5 to test the extent to which this taxonomy provides a useful description of the navigator's cognitive model of his/her navigation task. Route Choice and Location were two skills illustrated in the first iteration of this prototype. The response from a small sample of orienteers was positive. Their comments are being incorporated into revisions of the prototype. An expanded prototype is currently being developed.

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Zusammenfassung


References


Communications

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INJURIES IN ORIENTEERING

A STUDY OF THE 1991 SWISS 6-DAYS ORIENTEERING EVENT

Beat Hintermann and Max Hintermann

Abstract

The injuries requiring first aid treatment during the 1991 Swiss 6-day event are presented and compared with previous reports. Of the 2160 participants, there were 2.3 injuries noted per 100 competitive performances, in which the injury rate was similar to that of other events in Great Britain and Scandinavia. Ankle sprain and cuts were the most common injuries. The special problems in injury registration at such an event are discussed.

Introduction

Orienteering has become a global sport. Generally run in hilly, forested areas, orienteering courses present such terrain features as crags, boulders, cliff faces, gullies, rivers, streams, marshes and brambles. The nature of the terrain, the varied level of fitness of the participants, and the wide age range of the orienteers, from under 10 to over 60, are all factors in which different injury patterns for acute injuries may be expected.

Injuries in orienteering events have been the subject of previous reports. Johansson (1986a, 1986b, 1988) and Linde (1986) focused on injuries among elite competitors during training and competition. Orava & Puranen (1979), Kujala, Kvist & Östermann (1986) and Kannus, Aho, Järvinen & Niittymäki (1987) revealed the types of injuries presented by orienteers in Finland and compared them with those of participants in other sports. Folan (1982) studied all injuries at the Irish National Championships in 1981, and determined a percentage injury
rate of 5.26% for the 285 individual competitors. Korpi, Haapanen & Svahn (1987) considered the FIN-5 International 5-day event of 1984 and the Finnish Night Championships of the following year on the basis of 569 visits to the first aid service. McLean (1990) found in his study at the Scottish 6-day event 1989, and the Jan Kielstroem Memorial event 1990, 2.21 injuries per 100 competitive performances at the former but only 1.42 at the latter. Similar to the previous reports, ankle sprains and cuts were the most common injuries. Finally, Ekstrand, Roos & Tropp (1990) investigated the relationship between participation time and ankle sprains in competitive orienteering. Of the 658 injuries, 137 (23.9%) were ankle sprains.

All these reports concern orienteering in Scandinavia and Great Britain. To our knowledge, no similar study exists about orienteering in Central Europe. The purpose of this study was to summarize the first aid activity at the Swiss International 6-day event in 1991, and to assess the injury pattern.

Material and Methods

The Swiss International 6-days Orienteering event in 1991 was divided into two parts. The first 3 legs were held in the Juras, and the second 3 legs in the foothills of the Alps. The terrain for both parts was hilly, mixed forests, rather dense but significantly steeper in the foothills. The ground changed, from grass to fern, and from rock to marsh. The weather was mostly sunny and hot, with some thundershowers in the evening. The terrain was significantly wet only in the sixth leg. The first 3 legs were performed on 3 consecutive days, and the second 3 legs on 3 other consecutive days after an interval of 2 days. Since the 2 parts were organized by different clubs and mainly independently, the first aid service was performed by different teams. However, during the whole event a medical doctor was present at the first aid station close to the finish line. He was supported by a paramedical team of 6 people which was divided into 3 groups: 2 groups in the competition area and one group at the first aid station. The distance from the first aid station to the nearest provincial hospital was less than 10 km. In addition to this first aid service, free medical consultation was offered in the evening during the second part (leg 4-6), supported by an orthopaedic surgeon and a cardiologist. These consultations allowed practitioners to review competitors, injuries and chronic complaints on-site without removing competitors from the events.
An acute injury was defined as any traumatic injury requiring a visit to a doctor. However, bagatelle injuries which were seen and treated only by the paramedical people, were not considered as injuries. All details of the injured competitors were registered as well as the circumstances of the accident.

Results

During the second 3 days of this 6-day orienteering event, there was a total of 233 visits to the first aid station, 31 of which were not due to injuries. The injuries treated and the other conditions requiring treatment are shown in Table 1. The 151 injuries correspond to a frequency of 2.3 injuries per 100 competitive performances. Table 2 gives a summary of the injuries and their localisations.

Table 1. Injuries and other conditions treated (the 51 bagatelles treated by the para-medical people are not included).

<table>
<thead>
<tr>
<th>Skin injuries</th>
<th>79</th>
</tr>
</thead>
<tbody>
<tr>
<td>- cuts</td>
<td>40</td>
</tr>
<tr>
<td>- grazes</td>
<td>16</td>
</tr>
<tr>
<td>- blisters</td>
<td>11</td>
</tr>
<tr>
<td>- bites</td>
<td>8</td>
</tr>
<tr>
<td>- toe nail injuries</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Injuries to the locomotor system</th>
<th>72</th>
</tr>
</thead>
<tbody>
<tr>
<td>- bruises</td>
<td>11</td>
</tr>
<tr>
<td>- sprains</td>
<td>48</td>
</tr>
<tr>
<td>- luxations</td>
<td>5</td>
</tr>
<tr>
<td>- fractures</td>
<td>2</td>
</tr>
<tr>
<td>- strains</td>
<td>5</td>
</tr>
<tr>
<td>- tendon injuries</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No injuries</th>
<th>32</th>
</tr>
</thead>
<tbody>
<tr>
<td>- infections</td>
<td>8</td>
</tr>
<tr>
<td>- sickness</td>
<td>4</td>
</tr>
<tr>
<td>- exhaustion</td>
<td>2</td>
</tr>
<tr>
<td>- miscellaneous</td>
<td>18</td>
</tr>
</tbody>
</table>

Total                           | 183 |
**Table 2.** Distribution and localisation of the injuries.

<table>
<thead>
<tr>
<th>injuries</th>
<th>bagatelles</th>
</tr>
</thead>
<tbody>
<tr>
<td>head, neck</td>
<td>14</td>
</tr>
<tr>
<td>body</td>
<td>9</td>
</tr>
<tr>
<td>upper extremity</td>
<td>14</td>
</tr>
<tr>
<td>pelvis</td>
<td>3</td>
</tr>
<tr>
<td>thigh</td>
<td>13</td>
</tr>
<tr>
<td>knee</td>
<td>24</td>
</tr>
<tr>
<td>shank</td>
<td>16</td>
</tr>
<tr>
<td>ankle</td>
<td>39</td>
</tr>
<tr>
<td>foot</td>
<td>19</td>
</tr>
<tr>
<td>total</td>
<td>151</td>
</tr>
</tbody>
</table>

Ankle sprains were the most common single injury accounting for 23.8%. The lower limb was the region of the body most affected. Cuts and bruises were found on the whole body, without predominance of any special part. Most were caused by barbed wire. The anti-tetanus cover was inadequate in 31 cases (27.1%). Nine of these casualties were taken to the hospital for adequate wound treatment. In addition, 6 injured competitors were transported to the hospital for further investigation (X-ray) and treatment, but nobody needed to be admitted. In 13 other cases, further medical care at home was advised and recommended.

There were 2 confirmed fractures and 3 confirmed dislocations. The fractures affected the distal radius and the calcaneus. The dislocations concerned the shoulder (once) and the patella (twice).

**Discussion**

The types of injury experienced by recreational orienteers in Switzerland correspond with those in Scotland (McLean, 1990), Ireland (Folan, 1982) and Scandinavia (Korpi et al., 1987, Ekstrand et al., 1990). However, the proportions of each type of injury vary among the countries. Possible explanations for this may be local differences in terrain or clothing.
On the other hand, it may still be difficult or not realizable to register all injuries suffered in an orienteering event, since an unspecified number of injured competitors neglect the injury at first, or prefer to treat by them-selves respectively or by their physicians at home. This becomes relevant mainly in overpopulated countries like Switzerland, where the small geographical distances are such that medical care has not to be given in the sport place in any case. This may explain our observations that there were significantly less consultations after the final competition, and the relative amount of foreign competitors was significantly higher on that day. The fact that the competition is over may lead to less attention being paid to an injury. As shown also in previous studies (Ekstrand et al., 1990, McLean, 1990), the hypothesis that tiredness towards the end of a week of orienteering gives an increased risk of injury could not be supported by our observations. In summary, although such statistical evaluations have to be considered carefully, all these factors might explain the minimally lower injury rate found in a similar orienteering event in Sweden (Ekstrand et al., 1990).

In accordance with McLean (1990), the injuries in such an orienteering event differ from those in elite competitors during training and competition periods (Johannson 1986a, 1986b, 1988). We also found more wounds, especially on the hands, which could be the result of a higher tendency to fall in less trained orienteers and partially to a very steep terrain. However, as mentioned, it is very difficult to record all incidents in orienteering which provide evidence of how difficult a statistical analysis is to make.

Since orienteering competitions demand high intensity running in rough and uneven terrain, it is no surprise that recent and overuse injuries on the lateral ankle ligaments are common. Our founded rate of ankle sprains (23.8%) was similar high to other studies (Johannson, 1986a; McLean, 1990). However, the problem of ankle instability appears to be more relevant in orienteering than generally assumed (cf. Hintermann & Hintermann, pp. 79-86 in this journal).

This study supports previous studies confirming that orienteering is a safe sport with few serious injuries. However, there is a need for prevention of unnecessary injuries that affect the sport, and the competition results. Adequate dressing and reinforcement of the knees of O-suits, as demanded also by McLean (1990), may reduce the incidence of wounds which take long time healing especially around the knee joint, mainly when the burse is also affected. Education to encourage greater use of anti-tetanus immunization would also be
helpful. Our record of those wounded whose anti-tetanus was inadequate, 31 orienteers (27.1%) could not remember being immunized within the previous 10 years (Folan, 1985).

Our results support that first aid provision at a summer event should expect to treat about 3% of all starters. It does not appear that the injury rate depends on such a 6-day event on terrain, weather or tiredness of the orienteers, and there seems to be no difference between Central Europe and Great Britain or Scandinavia. It may be that orienteers pay certain attention to these factors. However, the injury pattern may show significant differences. We agree with McLean (1990) that, in providing first aid service, the knowledge of the treatment of ankle sprains, wounds, tick bites, muscle strains and blisters would cover most incidents. Facilities for suturing wounds may be appropriate when the distance to the nearest installed medical care is too far. Concerning the conditions in Switzerland, we still believe that this can be delegated to the local medical facilities.

Zusammenfassung

Aufgrund der Erst-Hilfe Konsultationen werden die Verletzungen am Schweizer 6-Tage-OL 1991 analysiert. Bei 2160 Startenden wurden 2.3 Verletzungen pro 100 geleisteten Orientierungsläufen gesehen. Dies entspricht in etwa den gemachten Beobachtungen an ähnlichen Anlässen in Schottland und Skandinavien. Art und Verteilung der Verletzungen waren ähnlich, wobei ebenfalls Hautverletzungen (45.7%) und Sprunggelenksdistorsionen (23.9%) am häufigsten waren. Trotz der moderaten relativen Verletzungsinzidenz kann gefolger werden, dass Orientierungslauf kein gefährlicher Sport mit häufigen schweren Verletzungen ist.

References


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ANKLE SPRAINS IN ORIENTEERING - A SIMPLE INJURY?

Beat Hintermann and Max Hintermann

Summary

Injuries to the lateral ligaments of the ankle were the most common injuries at the Swiss 6-day Orienteering event 1991. Of the 151 injuries 36 (23.8%) were ankle sprain injuries. In 11 casualties (30.6%) it was the first injury, whereas in the other 25 (69.4%) it was a reinjury. For the latter group with reinjury, it has to be concluded that most of the previous treatments were insufficient. A primordial function of each physician responsible for first-aid care on an orienteering event is to make sure that any injury to the lateral ankle ligaments gets an adequate treatment. Additional biomechanical considerations show how important the integrity of the whole capsular-ligamentous apparatus is, not only for the stability of the ankle, but also for the movement transfer between foot and shank which is of significant importance in running. Disorders may result in overuse injuries.

Introduction

Ankle sprains are the most common injury in sport activities (Ekstrand, 1982; Garrick, 1977). A high incidence of ankle sprains in orienteering was previously reported. At the Swedish O-ringen 5-day event in 1974, 127 (27.0%) of the 478 registered injuries were ankle sprains (Ekstrand, 1982). At the same event in 1987, of the 655 injuries 137 (23.9%) ankle sprains were found, corresponding to an incidence of 1.8 ankle sprains per 1000 hours of competitive activity (Ekstrand, Roos & Tropp, 1990). In his injury analysis in elite orienteers, Johansson (1986) determined that in 57% stress injuries and 43% traumatic injuries, ankle sprains accounted for 57% in the latter group. However,
in the same study, the severity of ankle sprains was supposed to be moderate in 81.2% of the cases (Johansson, 1986). No study included information about specific history dates or about the following treatment. It has been suggested that athletes with previous ankle sprain injuries run an approximately 2.3 times higher risk of reinjury (Ekstrand, 1982; Tropp, Askling & Gillquist, 1985).

The purpose of this investigation was to study the etiology of the ankle sprain injuries in orienteering. Special attention was also paid to the hind- and midfoot static as well as to biomechanical considerations.

Method

As described in detail in another contribution in this journal (pp. 72-78), injured athletes at the Swiss International 6-day Orienteering event in 1991 were examined and treated in the first aid station close to the finish line. Additionally, a free medical consultation was offered in the evening by an orthopaedic surgeon and a cardiologist. This permitted then to review and reinvestigate injured competitors under better locale and time circumstances, and to focus especially on overuse injuries. An acute injury was defined as any traumatic injury suffered during this 6-day event which required a visit to a doctor.

In the case of an ankle sprain injury, the injured orienteer was interrogated about previous ankle sprain injuries, the previous treatment and measures taken in preventing reinjuries. Then, a clinical investigation was performed and swelling and pain pattern documented. Because of pain, a mechanical testing of the ankle stability was mostly not possible. In severe cases of injury, a radiological assessment in the hospital was added in order to make sure that there was no bony lesion.

In any case of first ankle sprain injury, after a few days when the pain would be less a mechanical testing was suggested in order to define the ligament injury quantitatively. However, this second investigation was performed by an orthopaedic surgeon in the home country of the athlete where the physician received a detailed report of the first investigation. The result of this reinvestigation was also included in this study.

When the recent injury concerned a chronic instability with typical acute pain without significant swelling, a mechanical testing of the lateral ankle ligaments was possible in most cases after some hours. At the medical consultation in the evening, a more extended investigation was performed. Usually, an ankle taping was performed and, in some cases, a participation on the following day was even possible. However, a
reinvestigation to establish the definitive treatment was suggested in any case. Subsequently, a report for the orthopaedic surgeon at home was made. The result of the findings and decisions were also included in this study.

Results

Of the 151 competitors seen due to an injury, 36 (23.8%) presented a sprain injury of the ankle (Table 1). A first injury was revealed in less than a third of the cases. Table 2 presents treatment and preventative measures taken after a previous injury.

Table 1. Sprain injuries.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>first injuries</td>
<td>11</td>
</tr>
<tr>
<td>moderate</td>
<td>4</td>
</tr>
<tr>
<td>severe</td>
<td>7</td>
</tr>
<tr>
<td>reinjuries</td>
<td>25</td>
</tr>
<tr>
<td>1 previous injury</td>
<td>8</td>
</tr>
<tr>
<td>&gt; 1 previous injuries</td>
<td>17</td>
</tr>
<tr>
<td>Total</td>
<td>36</td>
</tr>
</tbody>
</table>

Table 2. Previous treatments after injuries (n=25) and preventative measures (also combinations).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>9</th>
<th>(36%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>surgical repair</td>
<td>9</td>
<td>(36%)</td>
</tr>
<tr>
<td>plaster</td>
<td>1</td>
<td>(4%)</td>
</tr>
<tr>
<td>MIKROS-brace</td>
<td>6</td>
<td>(24%)</td>
</tr>
<tr>
<td>ankle taping</td>
<td>7</td>
<td>(28%)</td>
</tr>
<tr>
<td>no specific treatment</td>
<td>9</td>
<td>(36%)</td>
</tr>
</tbody>
</table>

When the recent injury occurred only one of the 36 orienteers was wearing an ankle taping. Nine of the injured competitors, all with a
previous injury, normally used a MIKROS-brace or an ankle taping in orienteering, but they did not wear it at the time of the recent reinjury. Most of them stated that they had forgotten it to do or to bring the material on the event.

In the group of reinjury, the inspection of the hind- and midfoot static showed mostly a predominance of excessive eversion (pronation) combined with internal rotation of the leg. The shoes were typically worn out more on the medial side, with break-down of the medial heal support which may be concluded to be from a gait pattern with tendency to hyperpronation. The specific interrogation and investigation about typical overuse injuries is shown in Table 3. Since there was too much pain and swelling in most of the athletes with a first ankle sprain injury, a similar analysis was not possible.

Table 3. Overuse injuries in orienteers with chronic ankle instability (n=25).

<table>
<thead>
<tr>
<th>Injury</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achilles peritendinitis</td>
<td>5</td>
</tr>
<tr>
<td>Chondropathia patellae</td>
<td>4</td>
</tr>
<tr>
<td>Iliotibial friction syndrome</td>
<td>2</td>
</tr>
<tr>
<td>Medial shin pain</td>
<td>2</td>
</tr>
<tr>
<td>Pes anserinus tendinitis</td>
<td>1</td>
</tr>
</tbody>
</table>

Discussion

In their anatomical investigations, Ludolph & Hierholzer (1986) found a significant variety in the anatomy of the lateral ankle ligaments. Both, the anterior talo-fibular (atf) and the fibulo-calcanear ligaments (fc) originate on the anterior edge of the distal fibula and insert on the talus, respectively on the calcaneus, forming an angle of 105° (Inmann, 1976). The ligaments are supposed to be mainly stabilizing structures, and specific in-vitro studies were done to determine the joint laxity after selective cutting of the ligaments (Johnson, 1983). When a severe ankle sprain injury occurs, the atf is the first concerned (Rasmusson, 1985). By surgical exploration of 25 patients with an acute ankle ligament injury we found the atf was always torn, and in the case of a talar-tilting of 10 and more degrees, also the fc was torn (Hintermann, Holzach & Matter, 1990). In moderate injuries, when only the atf is affected, anterior instability of the talus results which increases in
plantarflexion. When the talus gets unlocked by anterior displacement in the mortise, also the fc becomes loosened (Hintermann, Holzach & Matter, 1992). In the case of inadequate and insufficient treatment, the anterolateral instability persists and the overstressed fc becomes looser with each reinjury. This may explain our observation, that, after the first injury to the ankle ligaments, the instability concerns mainly the ankle joint, whereas in chronic injuries the subtalar joint becomes even more unstable than the ankle joint (Hintermann, unpublished results).

Stormont, Morrey, Kai-Nan & Cass (1985) pointed out a significant influence of the loading on ankle joint stability, and he concluded that the ligaments seem to play a main role when the foot is unloaded till it gets loaded in the first part of heel contact. On the other hand, Sommer, Nigg, Hintermann & Van de Bogert (in press) found in their in-vitro investigations a predominant role of the ankle ligament in the movement transfer between foot and shank, under unloaded as well as under loaded conditions. After cutting of the atf and fc, even a higher amount of movement transfer was noted during eversion of the foot. That means that the anterolateral instability of the ankle leads to an excessive internal rotation of the leg, when the foot is everted, what corresponds to our observation that orienteers with chronic ankle instability showed a tendency to excessive internal rotation of the leg. It has to be assumed that many overuse injuries like medial shin pain, Achilles peritendinitis, chondropathia patellae, iliobial band friction syndrome or irritation of the pes anserinus may have the origin in excessive internal rotation of the leg during running. These symptoms represented more than 50% of the overuse injuries in a one-year prospective study of 42 elite orienteers (Linde, 1986). Similar results were found in young cross-country skiers (Hintermann, 1992).

Injuries to the lateral ligaments of the ankle require accurate diagnosis in each case, especially because most single injuries to the atf are not treated surgically any more. Different methods of conservative treatment are proved to have a high efficiency when applied: immobilization in plaster (Evans & Frenyo, 1984), braces (Fritschy, Junet & Bonvin, 1984; Jakob, Rämy, Steffen & Wetz, 1986; Zwipp & Tscherne, 1986) or taping combined with a stabilizing shoe (Hintermann, 1990). The possibility of preventing reinjuries with ankle taping (Garrick, 1973; Rovere, Clarke, Yates & Burley, 1988) and various ankle braces (Stover, 1979; Tropp et al, 1985) are well documented.

To recognize the severity of an ankle sprain injury and to establish an adequate treatment, whether it be surgically or conservatively, has to be
the primordial function of each concerned physician. That may often not be possible in the first aid station at an orienteering event.

However, as seen by our experience at the Swiss 6-day event in 1991, it signifies a major attention to make sure that this common injury gets adequate treatment. It demands an exact interrogation of the injured athletes about the specific history as well as an appropriate investigation and a precise establishment of the procedure. The additional medical consultation in the evening provided the possibility for reinvestigation as well as seeing and discussing the situation under better circumstances.

Our investigations confirmed how difficult it is to reveal the exact injury mechanism. On the other hand, we still do not believe that the knowledge of the exact injury mechanism may help to judge the severity of the injury, or decide about the treatment. However, it may help in the prevention of reinjury.

In conclusion, the rate of reinjuries to the lateral ankle ligaments in orienteering is too high. In many cases, it has to be suggested that the previous treatment was not adequate. Insufficient healing leads to a residual instability which also influences the movement transfer between foot and leg. Consecutive excessive internal rotation of the leg may be the reason for many of the common overuse injuries in orienteering.

Zusammenfassung

Am Schweizer 6 Tage-OL 1991 betrafen von den 151 Verletzungen 36 (23.8%) den fibularen Kapselbandapparat. In 11 Fällen (30.6%) handelte es sich um eine Erstverletzung, während in den andern 25 Fällen (69.4%) anamnestisch frühere Verletzungen erhoben werden konnten. Die dabei durchgeführte Behandlung war in viele Fällen ungenügend. Es stellte sich heraus, dass das Sicherstellen der weiteren Abklärung und definitiven Behandlung eine vordringliche Anforderung an jeden Wettkampfarzt ist. Zusätzliche Betrachtungen aus biomechanischer Sicht zeigen, dass die Integrität der fibularen Kapselbandstrukturen nicht nur für die Stabilisierung wichtig ist, sondern auch für die Bewegungsübertragung von Fuss auf das Bein. Eine Beeinträchtigung dieser Funktion kann zu Ueberlastungsbeschwerden führen.
References


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(Language: German. Pages: 68)
(Orienteering for blind and highly visually impaired. Modifications of a sport)
Two modifications of orienteering were developed with the aim to adapt the physical and technical demands to blind and highly visually impaired. The tactile map used consisted of a relief. The two components orienteering and running have been separated. First experiences are reported.

(Language: German. Pages: 40)
(Mental training in orienteering. Basis fondations)
After an analysis of the physical and mental demands of orienteering, the principles of cognitive training (concentration, perception, decision making, imagination), motivation training (motivation analysis and goal setting), psychophysical selfregulation (relaxation, stabilisation and activation) and emotion control (self suggestion, self confidence) are explained. This booklet gives the theoretical basis for working sheets written by H. Steinmann (see below).

(Language: English. Pages: 64. ISBN 1851370056)
(Orientierungslauf im Nationalen Lehrplan)
This guide for teachers shows how orienteering and map reading skills can be used to deliver attainment targets in geography, maths, and physical education and demonstrates how orienteering can form a topic of study having sound cross-curricular links.

(Language: German. Pages: 82)
(Mental training in orienteering. Working sheets)
Working material for mental training in orienteering, based on the theoretical booklet by A. Huber (see above). 12 steps to better
mental performance in orienteering: motivation analysis, goal setting, concentration, perception, decision making, relaxation, mobilisation, stabilisation, self confidence, self suggestion, imagery, and self control.

RELATED FIELDS

(Language: German)
(Consideration of functional anatomy when using adhesive tape at the upper ankle joint/foot)
The use of adhesive tape has proved to be a good alternative to treat several types of trauma and overuse syndroms at the upper ankle joint and the foot. According to the different injuries and problems the varied uses are presented. Especially the importance of the functional anatomy is emphasized for initiating a successful taping procedure. The techniques presented are offered merely as recognized methods which have been found effective and which should stimulate to improve this type of treatment. (Journal Abstract)