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Defining the Individual Injury Profile of Recreational Runners: Integrating Off-Training and Subjective Factors into the Assessment of Non-Professional Athletes †

Juan Restrepo-Villamizar [1,*], Evert Verhagen [2] and Steven Vos [1,3]

1 Industrial Design, Eindhoven University of Technology, 5600 Eindhoven, The Netherlands; s.vos@tue.nl
2 Public and Occupational Health, VU University Medical Center Amsterdam, 1700 Amsterdam, The Netherlands; e.verhagen@vumc.nl
3 School of Sport Studies, Fontys University of Applied Sciences, 5600 Eindhoven, The Netherlands
* Correspondence: j.c.restrepo.villamizar@tue.nl; Tel.: +31-06-2445-9880

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Abstract: Non-professional runners make extensive use of consumer-available wearable devices and smartphone apps to monitor training sessions, health, and physical performance. Despite the popularity of these products, they usually neglect subjective factors, such as psychosocial stress, unexpected daily physical (in)activity, sleep quality perception, and/or previous injuries. Consequently, the implementation of these products may lead to underperformance, reduced motivation, and running-related injuries. This paper investigates how the integration of subjective training, off-training, and contextual factors from a 24/7 perspective might lead to better individual screening and health protection methods for recreational runners. Using an online-based Ecological Momentary Assessment survey, a seven-day cohort study was conducted. Twenty participants answered daily surveys three times a day regarding subjective off-training and contextual data; e.g., health, sleep, stress, training, environment, physiology, and lifestyle factors. The results show that daily habits of people are unstructured, unlikely predictable, and influenced by factors, such as the demands of work, social life, leisure time, or sleep. By merging these factors with sensor-based data, running-related systems would be able to better assess the individual workload of recreational runners and support them to reduce their risk of suffering from running-related injuries.

Keywords: running-related injuries prevention; recreational running; off-training factors; subjective factors

1. Introduction

Despite the popularity of running in modern society and its health benefits, running-related injuries (RRIs) affect many runners and represent a significant health and economic burden for individual and public health [1]. Several studies have revealed that novice runners face a significant risk of RRIs, with 17.8 (95% CI 16.7–19.1) injuries per 1000 h of running [2]. Unlike (semi-) professional athletes, novice and recreational runners have no or limited access to specialized in-lab screening procedures for sports medicine surveillance or personalized coaching. Instead, these runners rely on training programs and standardized wearable devices, such as sports watches and smartphone applications [3,4], to monitor and obtain insights regarding their physiological condition, physical activity, performance, and training sessions [5], yet, these products rarely consider subjective and off-training factors from the daily lifestyle and dynamics of people—for example, a stressful day at work, lack of sleep because of young children, reduced physical activity due to illness, or high physical activity levels due to an unplanned game of squash with friends [6]. The neglection of these subjective and off-training factors limits the understanding of the complexity of people's daily life [7], leading to potential underperformance, reduced motivation, and RRIs [6,8]. Furthermore, within the sport sciences, the need for broader and real-life research in terms of behavior, implementation context, intrinsic, extrinsic, and off-training factors has arisen. To this end, several methods and directions have been proposed. As shown in Figure 1, the Translating Research into Injury Prevention Practice (TRIPP) framework by Finch [9] adds two steps to the commonly cited 'Sequence of Prevention' framework by Van Mechelen et al. [10]. These two steps consist of (i) describing the intervention context to inform implementation strategies and (ii) evaluating the effectiveness of preventive measures in the implementation context. This suggests the importance of considering the real-life context of the sports setting to define the "true" effect of measures for injury prevention. Verhagen et al. [11] include behavioral and cognitive aspects into the development process of preventive measures or programs, ensuring that the proposed intervention does not only consider theoretical evidence, but also fits the beliefs of end-users. For this, van Wilgen and Verhagen [8] propose the consideration of intrinsic factors, such as gender, biomechanics, or psychological traits, and extrinsic factors, such as weather, environment, social life, training, or family, that underline injuries. Following this approach, prevention programs for injuries should incorporate both the somatic factors and the pre-existing beliefs of end-users about the intrinsic and extrinsic factors related to injuries [8]. As these approaches arose from the elite and competitive sports, ways to implement them into non-professional or recreational sport settings are less explored or not mentioned, yet, it is suggested that the heterogeneity of non-professional athletes requires an approach that integrates psychological, physiological, and contextual aspects to assess individuals as a distinctive approach and envisioning of societal and personal needs [12]. Vanhoren et al. [13] highlight the importance of understanding the motives of people to engage in and practice running, and the relevance of this to provide meaningful feedback to the runners. Moreover, the ONE23CYCLE framework [5] suggests considering training sessions as a single element of a more complex structure, composed of 24/7 training, off-training, and environmental factors that underline the individual workload profile of non-professional athletes.

The aim of our exploratory study is to obtain insights on how to integrate subjective, contextual, extrinsic, and off-training factors into the assessment of recreational runners. We further want to obtain insights on the potential of integrating these factors with current sensor-based solutions to support recreational runners on reducing their risk of suffering from running-related injuries, improving performance and general healthy habits.

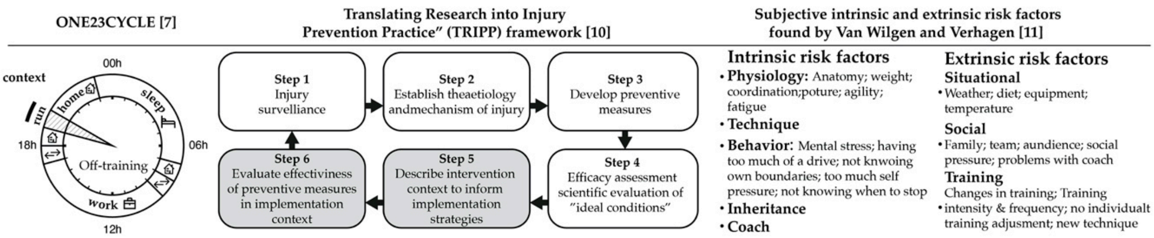

Figure 1. Approaches that articulate context, subjective, and 24/7 factors for injury prevention research and implementation.

2. Method

2.1. Participants

Following institutional ethical approval (ERB2019ID3) granted by the Ethical Revision Board from the Eindhoven University of Technology, an invitation was sent via email to thirty potential participants who had expressed their willingness and interest to be part of upcoming studies. The inclusion criteria for participants were to be physically active, physically and mentally healthy, enrolled in running or other type of sports or fitness activities, and familiar with using mobile devices and mobile apps. In total, twenty participants (nine females, 11 males between 21 and 52 years old) volunteered to be part of the study. Within the invitation, the instructions and details of the study were shared with all volunteers. All participants were injury free at the beginning of the study. Participants provided written informed consent regarding participating in the study.

2.2. Study Design

To obtain insights on how to integrate subjective measures into the assessment of recreational runners, a set of contextual, health, and physical performance-related factors, such as sleep, psychosocial stress, and training, was defined. The relevance of sleeping and its direct impact on physical recovery for optimal athletic performance and general health benefits has been recognized by several studies [14–16]. To obtain insights on the subjective experience of sleep quality and its potential to enrich the overall understanding of recreational athletes' recovery time, the sleep quality perception scale from The Pittsburgh Sleep Quality Index (PSQI) [17] was implemented. Besides sleeping, psychosocial stress has been recognized as an important influencing factor on people's general health and wellbeing. High levels of psychosocial stress have been linked to insomnia, physical underperformance, poor recovery, and health conditions [18–20]. To obtain insights on the role of psychosocial stress and the stressors on people's daily routine and training behavior, the participants were asked to provide subjective ratings of their stress perception based on a five-point scale and a daily descriptive stressors questionnaire. Additionally, training factors linked to physical performance, risk of injuries, and physical load, such as training frequency (the number of training sessions per week), training duration (length of the training sessions), training intensity (subjective rating of the level of effort a person exerts during exercise relative to his or her maximum effort), and type of training were considered. As shown in Figure 2, injury history and subjective factors for training absence or training modification, such as lack of time, physical pain, illness, physical and mental fatigue, or physical pain or discomfort, among others, were also considered to gain insights on people's training behavior.

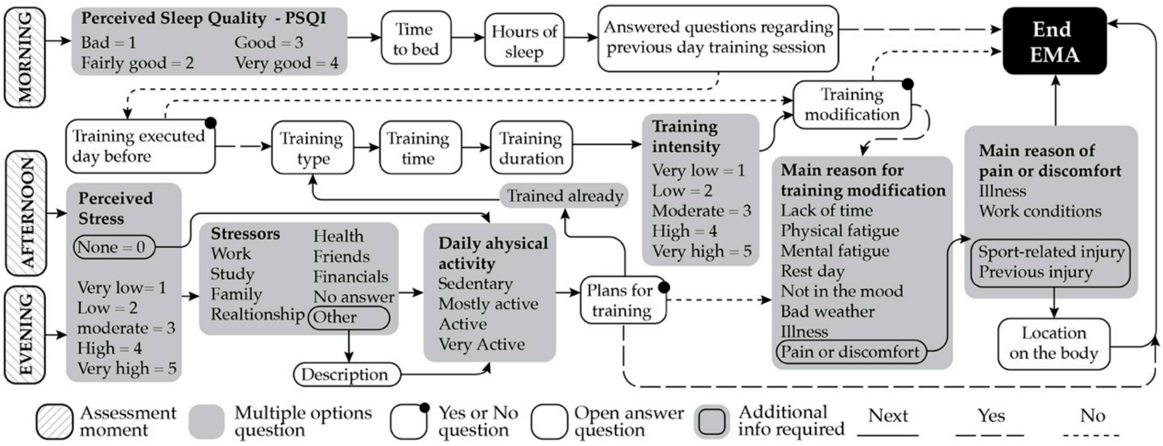

Figure 2. Structure of the mobile app Ecological Momentary Assessment (EMA) survey, and description of the data collected in the assessment moments.

2.3. System Design

An Ecological Momentary Assessment (EMA) survey was developed to collect 24/7 daily subjective data (see Figure 2). The survey included a demographics questionnaire to be filled out by the participants at the beginning of the study. The survey collected data during three moments of the day (morning, afternoon, and evening) for a period of 7 days. To deploy the survey among all participants, the researchers implemented PIEL Survey [21], an open source EMA mobile app developed for research purposes [21] that focused on acquiring a more nuanced understanding of a participant's patterns of thoughts and feelings than traditional survey methods. It allowed researchers to schedule momentary assessment surveys, which ran daily questionnaires and stored data in each participant's smartphone. During the 7 days of the study, the participants were asked to answer a demographics questionnaire and received three push notifications every day to answer three different daily surveys, as shown in Figure 2. In total, each participant answered 21 daily surveys composed of multiple questions, for a total of 420 daily assessment moments among all responders.

3. Results

Twenty participants submitted their data via the PIEL Survey app. Four of them did not answer all the daily surveys, and their answers were not considered in the results. Five out of the resultant sixteen participants (females = 8, males = 8) were reported to be single, five married, and three in a relationship. Seven participants reported to having children, all under the age of 18. Besides running, the participants reported to being involved in other types of sports and physical activities, such as athletics, yoga, cycling, swimming, squash, field hockey, fitness, weightlifting, calisthenics, CrossFit, fencing, kendo, golf, and soccer. Five participants reported to being novice runners (<6 months), one intermediate (6 to 18 months), and five experienced (>18 months). Five participants reported previous RRIs, such as calcaneal spur, sagging forefoot with pincher nerve, plantar fasciitis, runner's knee, and Achilles rupture. A total of 114 days of data collection were reported. An overview of the daily collected data is shown in Figure 3.

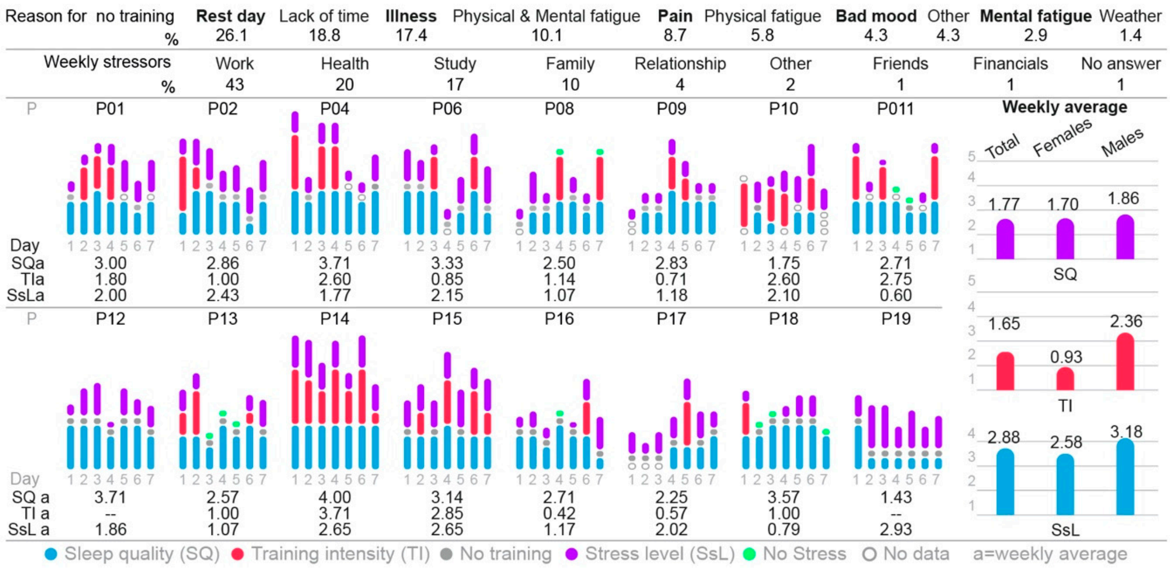

Figure 3. Results overview: visualization of the heterogeneity and diversity of participants' daily life in terms of sleep quality perception, training behavior, training intensity perception, and psychosocial stress perception.

During the period of the study, the participants reported a daily average of 7.1 h of sleep and a mean of 2.88 (max = 4) of their perceived sleep quality, equivalent to good sleep in the PSQI. The participants reported 38 days in which training sessions were executed with a total of 2272.5 min of training; 69 days of no training execution; and 7 days in which no training-related data were logged. The participants scored the weekly average of the perceived training intensity as low = 1.65 (5 = max, equivalent to the subjective rating of the level of effort a person exerts during exercise relative to his or her maximum effort). Female participants rated their training intensity perception as very low, with a mean of 0.93 (5 = max), while males reported it as low, with a mean of 2.36 (5 = max). During the 69 days in which no training was performed, the participants reported rest day with 18 days (26.1%) to be the main reason for no training execution, followed by lack of time with 13 days (18.8%), illness with 12 days (17.4%), physical and mental fatigue with 7 days (10.1%), and physical pain or discomfort with 6 days (8.7%), representing the 81.2% of the reasons for no training execution. The remaining 18.8% was composed by physical fatigue, bad mood, mental fatigue, and bad weather. Furthermore, the participants rated their perceived psychosocial stress as low, with an average weekly score of 1.77 (5 = max). Complementary, work was reported to represent the 43% of the daily stressors, followed by health with 20%, study with 17%, and family with 10%. Friends, financials, other specific reason, or the desire to not to answer this question were reported, too.

In Figure 4, a detailed description and comparison of four different participants is shown, which evidences the heterogeneity and complexity of participants' training, daily behaviors, and feelings. According to the results, P02 was a 42-year-old experienced male runner, who reported 5 days without training due to illness, a fact probably reflecting his concern about his own health as a daily stressor. On the other extreme of Figure 4, P19 was a 43-year-old novice female runner, who did not execute any training session during the week, mainly due to physical and mental fatigue. She reported to being experiencing age-related hormonal disorders, which were directly linked with her poor sleep quality, absence of training, and a prevalence of physical and mental fatigue during the period of the study. While P12 reported a similar training behavior as P19, the main reason for no training execution was physical pain on his knee caused by repetitive strain sustained during a long road trip in the week before the period of the study. Unlike P02, P12's physical constraints did not represent a significant source of stress or sleeping difficulties. P08 reported a more diverse routine in terms of sleep quality, training behavior, and daily stressors. These findings clearly exemplify how and why each participant needs a different type of support, approach, and feedback based on their specific needs, context, and conditions. The fluctuations and differences of motives, attitudes, and feelings among participants and with themselves represents a challenge to be addressed in the development and implementation of future supporting technologies for non-professional athletes and runners.

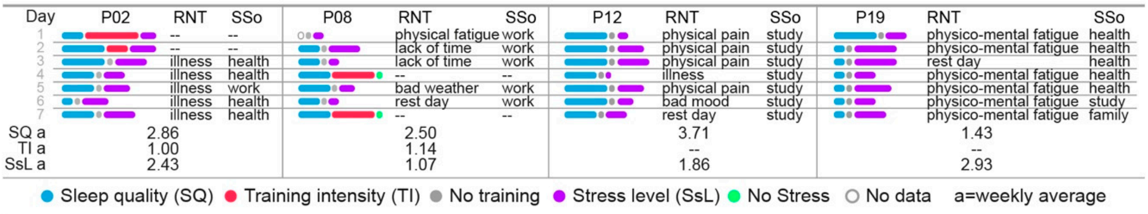

Figure 4. Evident heterogeneity of motives and causes for training behavior among and within participants.

4. Discussion

The results provided by sixteen participants showed that the unstructured—and unlikely predictable—training behaviors of recreational athletes are influenced by subjective and off-training factors that differ not only between individuals, but also within them. This study serves as preliminary evidence to support the claim for the need to consider subjective and off-training factors in the development of methods to assess and support non-professional athletes.

While the main limitation of this study was its sample size and duration, it was possible to get an overview of the potential of subjective and off-training factors and momentary assessment tools to reveal crucial individual-related information. This could be implemented by equipping sport-focused wearable devices and mobile apps with self-reporting tools to conduct subjective measures. For instance, after a training session, a user might be notified to rate the perceived intensity of that specific training, providing meaningful insights to better understand the way the she feels about her own condition, or, when the training behavior seems to decay (e.g., skipping training sessions, reducing intensity of exercise), the system should ask the user for the reason behind that change (e.g., illness, holidays, injury). As a result, the system would be able to deliver better feedback and suggestions for training adjustments accordingly. This might contribute to the development and implementation of methods focused on supporting people in achieving a better, healthier, and injury-free life through physical activity and sports.

5. Conclusions

The participants reported very heterogeneous and fluctuating results and patterns regarding their sleep quality, training behavior, and psychosocial stress perception and its sources. By implementing an EMA survey, contextual, intrinsic, extrinsic, and off-training factors that might underline individual load, capacity, and risk of injuries were revealed. Further research should be done on a bigger sample size, and on integrating subjective, off-training, and contextual factors with sensor-generated data. This will allow us to obtain insights on how to merge these approaches into real-life solutions to support non-professional runners on a personal and individual level. In conclusion, this study gives promising results for the use and integration of subjective and off-training factors in the assessment and support methods for non-professional athletes, novice, and recreational runners.

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Conflicts of Interest: The authors declare no conflict of interest.

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