Sport-Specific Outdoor Rehabilitation in a Group Setting: Do the Intentions Match Actual Training Load?

Jeroen de Bruijn, Henk van der Worp, Mark Korte, Astrid de Vries, Rick Nijland, and Michel Brink

Context: Previous research has shown a weak relationship between intended and actual training load in various sports. Due to variety in group and content, this relationship is expected to be even weaker during group rehabilitation. Objective: The goal of this study was to examine the relationship between intended and actual training load during sport-specific rehabilitation in a group setting. Design: Observational study. Setting: Three outdoor rehabilitation sessions. Participants: Nine amateur soccer players recovering from lower limb injury participated in the study (age 22 ± 3 y, height 179 ± 9 cm, body mass 75 ± 13 kg). Main Outcome Measures: We collected physiotherapists’ ratings of intended exertion (RIE) and players’ ratings of perceived exertion (RPE). Furthermore, Zephyr Bioharness 3 equipped with GPS-trackers provided heart rate and distance data. We computed heart rate–based training loads using Edwards’ method and a modified TRIMP. Results: Overall, we found weak correlations (N = 42) between RIE and RPE (r = 0.35), Edwards’ (r = 0.34), TRIMP mod (r = 0.07), and distance (r = 0.26). Conclusions: In general, physiotherapists tended to underestimate training loads. To check whether intended training loads are met, it is thus recommended to monitor training loads during rehabilitation.

Keywords: session RPE, athletic injury, return to sport, heart rate

Soccer and injury are inseparably linked together. A professional soccer player sustains on average 2 injuries every season, thereby missing 37 days each season (ie, about 12%). We can also find high injury rates in amateur soccer. In Dutch amateur soccer, 60.1 percent of 274 players got injured during a regular season. A player’s absence due to injury will not only affect performance but it may also have serious financial consequences. Avoiding injury should therefore be a top priority for coaches, strength and conditioning trainers, and medical staff. In spite of all efforts, a certain chance of injury will always remain, especially if collisions are an integral part of the sport. For this reason, it is crucial to minimize the impact of injury by optimizing injury rehabilitation. A proper rehabilitation process should allow players to return to sport safely within a minimal time span.

In the process of returning to sport, there are different phases that we can distinguish. The rehabilitation process starts with a clinical phase with the objective to repair and strengthen damaged tissue. This phase is usually general in content and takes place individually. It consists of strength and balance exercises under personal supervision of the physiotherapist. Moving forward through the process, rehabilitation tends to gradually get more specific and the clinical setting is often traded for a sport-specific setting. The emphasis during the last phase of rehabilitation is on preparing the player to successfully return to sport.

An important aspect of this last phase is the prevention of reinjury. Research shows that there is a tendency to return to sport too early, causing injuries to reoccur. This study shows that 73% of rehabilitated basketball players get reinjured due to returning to sport too early. Moreover, another study shows that previous injury is the main risk factor for injury. After previous injury the risk of another injury is 2 to 3 times higher. Most of those injuries are recurrent injuries, although in some cases they are anatomically unrelated. This indicates that rehabilitation is a process that should not be rushed and that the moment of returning to sport should be determined carefully.

Another important objective of the sport-specific phase of rehabilitation is to improve players’ fitness in order to allow them to perform at preinjury fitness levels. Sports injury inevitably leads to training reduction or training cessation. As a result, a process called detraining occurs and this affects both cardiac and muscular performance. Reductions in cardiac and muscular performance cause VO₂max to decrease and aerobic endurance to decline. Well-trained endurance athletes have been shown to lose around 15% of their VO₂max after 12 weeks of training cessation, with a decline of 5–10% within the first 4 weeks. Considering that the duration of inactivity as a result of medical and surgical treatment and following rehabilitation ranges from a few weeks to several months, one can easily imagine that an injury seriously affects a player’s aerobic fitness. Fortunately, the negative effects of detraining on aerobic performance can be reversed by endurance training. To accomplish this, training loads during the rehabilitation process have to be build up and be thoughtfully managed.

The sport-specific phase of the return-to-play process is usually completed in groups and in a sport-specific setting (eg, a soccer field). The group setting enables the physiotherapist to simulate training and match scenarios, thus making the rehabilitation sessions more similar to real matches. Additionally, it allows the physiotherapist to train multiple participants at a time, thereby making it both cost- and time-efficient. However, there are also some disadvantages to rehabilitation in a group setting. Most importantly, it is very difficult to individualize the training and this makes players susceptible to under- and overtraining.
In order to fully comprehend this problem, it is important to distinguish between the internal training load and external training load. The external training load is the load provided by the coach or physiotherapist and it can be quantified by, for instance, measuring the distance that players cover. The internal training load is the actual physiological stress imposed on a player. This actual load can be quantified by using, for example, self-report measures like ratings of perceived exertion and physiological variables such as heart rate. However, the load that the coach or physiotherapist tends to impose on a player may not be equal to this actual load. This has been shown in various individual sports. Studies in both running and swimming demonstrate that the relationship between intended and actual training load is weak and that significant differences between them occur. It seems to be even more problematic to achieve the intended training load in team sports. Research in soccer shows that the relationship between intended and actual training load is very weak, and that coaches systematically underestimate training load during the competitive season. Hence, we can conclude that it is difficult for a coach to accurately achieve the desired individual training load especially during group exercise. This may be even more challenging in a rehabilitation setting, in which diversity in levels of competition, injury type, and phase of rehabilitation means that the heterogeneity of the group is more pronounced.

To the best of our knowledge, no scientific research has examined the relationship between intended training load and actual training load in a rehabilitation setting. As we mentioned earlier, managing and properly building up training load is crucial in a rapid and successful rehabilitation process. Therefore, the objective of this study is to examine the relationship between intended and actual training load during sport-specific outdoor rehabilitation in a group setting. Based on previous research in other sports-related domains, we expect differences between intended training load and actual training load.

**Methods**

**Participants**

Nine amateur soccer players participated in this study, 7 of which were male and 2 were female. The physical characteristics of the participants were as follows: age, 22.1 ± 3.1 years; body mass, 75.0 ± 12.6 kg; and stature, 1.79 ± 0.09 m. The participants were recovering from different lower limb injuries: anterior cruciate ligament (ACL) injury (6), posterior cruciate ligament (PCL) injury (1), hip injury (1), and bone fragments in the ankle joint (1). All participants had undergone surgery except for the PCL patient. They were 4–6 months postsurgery when they started the sport-specific rehabilitation and had participated in 5–8 sessions prior to the start of this study. Before participating, all players were verbally informed and received an information letter about the nature of the study, the associated risks, and their right to withdraw at any time during the study. They then provided written informed consent and the study was granted approval by the ethics commission.

Two sports physiotherapists with multiple years of experience supervised the rehabilitation settings. They had been involved in the participants’ rehabilitation for approximately 6 months on average before the start of the sport-specific rehabilitation sessions. Both had been performing outdoor rehabilitation sessions for several years.

**Design**

This study was an observational study in which we conducted measurements during 3 rehabilitation sessions. The number of participants attending the rehabilitation session varied from session to session due to personal rehabilitation plans and interference with other obligations (eg, work or school). No dropouts were recorded, resulting in 8 participants during the first training, 4 during the second, and 3 in the final session. The total duration of the sessions was 50 minutes to 1 hour. All rehabilitation sessions were identical in structure, consisting of a warm up and 2 core activities. The content of the 3 parts in each session was largely similar, though the duration was allowed to differ. The purpose of the warm up was to activate the players, get their muscle temperature up and make sure they were ready for high-intensity activity. It consisted of running 3 laps around the soccer pitch, some running sidesteps, cross steps, knee-lifts, and heel-lifts in the width of the pitch. In addition, it contained some stationary core-stability exercises to strengthen the players’ core muscles. The duration of the warm up was between 10 and 15 minutes. The purpose of core 1 and core 2 was to improve technique (passing, kicking, controlling the ball) and to increase endurance capacity and speed. Core 1 included several pass-and-run and dribble exercises, with the occasional chance to finish on goal. It took anywhere between 10 and 30 minutes. Core 2 was shorter in duration, 5–10 minutes, and usually consisted of short sprinting exercises with and without elastic resistance bands and often ended with a small-sided game. The rehabilitation sessions that we used for our measurements accurately represented the regular rehabilitation sessions in both content and structure.

**Procedures**

We asked the physiotherapists to give ratings of intended exertion (RIE) per participant for all 3 parts of the rehabilitation session. This process preceded each rehabilitation session. The physiotherapists rated intended exertion on a 15-point Borg scale. We also used the 15-point Borg scale to measure ratings of perceived exertion (RPE). We asked participants to give a rating of perceived exertion after every part of the rehabilitation session. They received instructions to rate every part of the training session as a whole, instead of focusing on an individual exercise.

We collected heart rate data using Zephyr Bioharness™ (Zephyr Technology Corporation, Annapolis, MD, US). This system consists of a chest strap, a data module, GPS-trackers, and a laptop including Zephyr™ software. The chest strap has the ability to measure heart rate due to 2 electrocardiogram (ECG) sensors and the GPS trackers can be easily attached to the chest strap using an additional pocket with Velcro. We used the trackers to collect distance data. Research has shown that Zephyr Bioharness™ is a reasonably accurate system for measuring heart rate in comparison to Vmax Metabolic Cart (VIASYS, Yorba Linda, CA) and the validated K4 b2 Portable Metabolic Measurement System (COSMED, Rome, Italy). This was confirmed by a study that found comparable results between Zephyr Bioharness™ and the Cosmed Quark CPET system (COSMED, Rome, Italy). This was confirmed by a study that found comparable results between Zephyr Bioharness™ and the Cosmed Quark CPET system (COSMED, Rome, Italy).

**Data Analyses**

We used the Zephyr™ software for the primary data collection, after which we converted the data to Excel files to allow for further analysis in Microsoft Excel (Microsoft Corporation®).
We first separated and organized data from the individual training parts (warm up, core 1, and core 2). Deleting the data from before, after, or between training parts and excluding them from further analysis was a necessary step within this procedure. For the primary analyses, we made no distinction between data from the 3 test occasions. We simply added data from participants that engaged in multiple test moments as additional data points.

To compute a training load (TL), we used the 15-point Borg scale scores from both RIE and RPE. Using the method described by Foster et al, we calculated training loads in arbitrary units (AU). According to this method, training loads can be calculated by multiplying the duration in minutes with the score on the Borg scale. We did this separately for the warm up, core 1, and core 2, using the recorded time for each training part.

Next, using Edwards’ method and a modified TRIMP, we quantified the heart rate data. We first estimated participants’ maximal heart rates (beats · min⁻¹) using the calculations shown in Equations 1 and 2.

\[
\text{Males : } HR_{\text{max}} = 202 - 0.55 \times \text{Age} \quad (1) \\
\text{Females : } HR_{\text{max}} = 216 - 1.09 \times \text{Age} \quad (2)
\]

Subsequently, we calculated the respective heart rate zones prescribed by both TRIMP methods. For Edwards’ TRIMP, we separated participants’ heart rates in 5 zones based on percentages of maximum heart rate, after which we gave each zone its proposed coefficient. We used the same procedure for Stagno’s TRIMP, but using modified heart rate zones and adapted coefficients. After that, we calculated training loads (AU) for both methods by taking the sum of the accumulated time spent in the respective zones multiplied by the corresponding coefficient. We gave a coefficient of 0 to heart rates below the respective minimal heart rate percentages of 50% and 65%. Using these methods resulted in 2 training loads per participant per training part.

Finally, we calculated the distance covered by the participants for all individual training parts. We took the sum of the distance covered per training part to get a measure of the total distance covered by each participant during a rehabilitation session.

Statistical Analyses

We used Microsoft Excel (Microsoft Corporation®) to produce descriptive statistics. This included means and standard deviations for the total data set (overall), and separately for the warm up, core 1, and core 2. We used SPSS statistical software (version 20.0; SPSS Inc, Chicago IL) for computing test statistics. Data were not normally distributed.

Using Kendall’s tau nonparametric correlation coefficient, we calculated correlation coefficients and significance of the relationships between RIE TL and the following variables: RPE TL, Edwards’s TL, TRIMP MOD, and distance. To quantify the difference between the physiotherapists’ intended load and actual load, we calculated mean differences between RIE TL and RPE TL in both arbitrary units and 15-point Borg scale points. We used the Wilcoxon Signed-Rank Test to test the differences in arbitrary units for significance.

For this study, we set the statistical significance at \( P < 0.05 \) and we calculated effect sizes (\( \eta \)) by dividing the standardized test statistic by the square root of the number of observations. Effect sizes higher than 0.5 represent a large effect, whereas values between 0.3 and 0.5 or below 0.3, respectively, indicate a medium or small effect.

Results

Descriptive Statistics

Descriptive statistics are shown in Figure 1. For both the individual training parts and for the total training, it displays means and standard deviations of the different training load methods and distance.

Test Statistics

In Table 1 correlations are shown between RIE TL and the different training loads and distance, for the individual training parts and all training parts together (overall).

Mean differences between RIE TL and RPE TL are displayed as arbitrary units and Borg scale (6–20) points in Figure 2. Positive and negative values respectively indicate an underestimation and overestimation.

Discussion

The goal of this study was to investigate the relationship between intended and actual training load during sport-specific rehabilitation sessions in a group setting. In general, the relationship between intended load and actual load was weak and depended on the measure of actual training load that was used.

We found a weak correlation between RIE TL and RPE TL overall, suggesting that the exertion perceived by the participants did not match the exertion intended by the physiotherapists. If we focus on the separate parts of the training, we can see that the correlation between RIE TL and RPE TL was weak during the warm up, but moderate to strong in core 1 and core 2. The physiotherapists underestimated training load overall and in core 1, but most severely in the warm up. Also, relationships between intended exertion and the 2 objective measures of internal training load based on heart rate proved to be weak. Overall, both Edwards’s TL and TRIMP MOD showed weak correlations with RIE TL, which is confirmed by the correlations in the individual training parts. These were all very weak, except for the strong correlation between RIE TL and Edwards’s TL in core 1. Distance covered, the other objective measure of external training load, had a weak correlation with RIE TL overall and in the individual training parts. Again, core 1 was the exception and we found a moderately strong correlation.

According to the ratings of intended exertion of the physiotherapists, the warm up was not supposed to be physically demanding. However, in reality all exercises during the warm up were performed at speed, allowing little or no rest in between and putting the players under almost constant physical stress. As a result, the training load was much higher than intended. On the other hand, training load was overestimated in core 2, probably because players were able to determine the intensity of the small-sided games themselves. In general, these results indicate that participants experienced the rehabilitations sessions to be more demanding than was actually intended by the physiotherapists. This is in accordance with a study in soccer that observed a similar pattern in training sessions.

On the whole, these results suggest that the physiotherapists did not manage to match the actual load with the load they intended. However, it can be argued that the training load methods used in this study are less suitable for sport-specific rehabilitation settings. Although the validity of these methods is well established in sports, there is a lack of knowledge concerning applicability in a rehabilitation setting. The heart rate methods we chose in this...
study were both derived from the original TRIMP method proposed by Bannister in 1991. The TRIMPMOD is especially suited for high-intensity exercise with an intermittent nature, which makes it appropriate for a team sport setting. However, several properties of the rehabilitation sessions in this study could affect the suitability of these measures. First of all, the participants in this study were recovering from injury and it is safe to assume that their cardiovascular fitness level was below that of the healthy athletes in the studies mentioned above. Second, the nature of the exercises during the rehabilitation sessions was diverse and not entirely aerobic. The main goal of the exercises was to increase coordination, balance, and strength, and therefore the focus was not exclusively on increasing cardiovascular capacity. Some exercises even allowed for completely stationary execution. Edwards’ method and Stagno’s modified TRIMP only take into account cardiovascular stress, and this, in combination with the other reasons we mentioned above, could affect the suitability of these methods for rehabilitation settings.

The difference between Edwards’TL and TRIMPMOD is illustrated by the correlation with RIETL in core 1. The correlation with Edwards’TL is very strong, whereas the correlation with TRIMPMOD is weak. Closer examination of core 1 and the corresponding heart rates revealed that participants were able to execute a substantial part of core 1 with a heart rate below 50% of their estimated maximum. The TRIMPMOD only scores heart rates above 65% of maximum. In contrast, Edwards’TL takes into account all exertion above 50%. This caused these loads to be considerably higher than those of the TRIMPMOD. As a result, there was a discrepancy between the correlations of Edwards’TL with RIETL and TRIMPMOD with RIETL. It is therefore important to consider that the intensity threshold of both methods, but especially TRIMPMOD, could be too high for proper application in rehabilitation.

The use of distance as a training load measure also produced some interesting results. In general, there was no relationship between the distance that participants covered during a rehabilitation session and the load that the physiotherapists had intended for them. It can be argued though, that distance is not a good reflection of external training load in sport-specific rehabilitation sessions. Namely, as we mentioned before, considerable parts of the rehabilitation sessions were stationary exercises that focused on aspects like core stability and balance. The fact that a moderately strong correlation was found in core 1 could be due to its content. The physiotherapists seemed to be able to determine the load accurately because they were able to set the distance that participants had to cover during the pass-and-run exercise, and besides that, it is likely that these exercises resembled training situations the closest.

Although a lot of research has been done on the relationship between intended and actual training load in a variety of sports,
our study was the first to focus on this relationship during sport-specific outdoor rehabilitation in a group setting. This had both its advantages and disadvantages. We applied multiple methods that were easy to use and we provided new insights in the match between intended and actual training load in a sport-specific rehabilitation setting. A limitation of our study was the absence of a maximal test to determine the participants’ maximal heart rate. Instead, we estimated maximal heart rate using a calculation. This may have affected the precision of the maximal heart rates and consequently could have influenced the outcomes of the heart rate-based methods. Yet, from experience with rehabilitation practices we can confirm that it is extremely rare that participants undergo a maximal test before or during their rehabilitation process. It may even be irresponsible to expose them to a maximal test considering their physical limitations and fitness level. So although estimating maximal heart rate was not an optimal choice, it was in accordance with normal rehabilitation protocol. Another constraint of our study was the small number of participants. A larger data set would definitely have been preferable, but due to the design of this study, in which participants were able to engage in multiple sessions, the number of data points was sufficient for the analyses. Unfortunately, we were limited to measuring just 1 group under supervision of 2 physiotherapists. Consequently, generalizability to other rehabilitation groups is limited.

Conclusions

In conclusion, we showed that during rehabilitation in a group setting the relationship between intended load and actual load is weak. In general, the physiotherapists tended to underestimate training load, especially during the warm up. The intended load was most closely achieved in core 1. Additionally, with this study we have given a first insight into the application of existing heart rate–based training load methods in a rehabilitation setting. Future research should focus on developing methods to accurately record internal training load in group-based rehabilitation sessions. A method that incorporates both aerobic, anaerobic, and mechanical measures should offer a superior representation of the diverse nature of rehabilitation. The implementation of accelerometer data may be crucial in this regard. Further research on the relationship between intended and actual training load during group-based rehabilitation sessions is needed in order to confirm and generalize the findings in this study.

Our results indicate that some practical issues should be addressed when using sport-specific outdoor rehabilitation in a group setting. Although rehabilitation in a group setting is more cost- and time-efficient, a mismatch between intended and actual training load may result in a suboptimal outcome. For this reason we advise to routinely compare $\text{RIETL}$ and $\text{RPETL}$, and to keep an eye on heart rates during sessions so that, if necessary, adaptations can be made instantly. However, it is important to consider that the purpose of these kinds of rehabilitation sessions is not merely to improve fitness levels. This means that if the actual training load is suboptimal, progression can still be made on other aspects of rehabilitation like coordination, balance, strength, and accustoming oneself to a competitive setting. It should be emphasized though, that the proper internal training load is important in increasing aerobic fitness. Moreover, when the load imposed on players is too high, this can increase the risk of reinjury. It is therefore recommended to check whether the intended training load is achieved by monitoring training loads during sport-specific rehabilitation sessions in a group setting.

![Figure 2](image-url)
Acknowledgments

We are grateful for the cooperation of Dannie Snijders during this study and we would like to thank Luuk Janssen for his role in the collection of the GPS-data.

References


