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The Effect of Heavy Training Weeks on the Psychological and Physiological Development of Professional Football Players

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Abstract

Athletes encounter heavy stressors throughout their whole careers. The precise effects of these stressors on psychological and physiological functioning on a longitudinal scale are not clear. In the present research we explore the possible effects of encountering and overcoming heavy training weeks on the psychological and physiological functioning of professional football players and to see if they bounce back, thrive under pressure, or succumb. We collected psychological (e.g. confidence) and physiological variables (e.g. heart rate) longitudinally as part of the daily routine with self-report questionnaires, and the average heart rate was monitored with Polar TeamPro. Then we conducted a group-based repeated measures ANOVA. Results of the study show that experiencing heavy training weeks in the past had a significant positive effect on recovery, RPE, and average heart rate at the beginning of the season. However, halfway through the season, the trend changed in the opposite direction. This suggests that fatigue could play a role in the latter half of the season. Next to this, no significant effects or trends were found for confidence. These results show the possible beneficial effects of heavy training weeks on psychological and physiological functioning but also outline the possible challenges that can arise at the end of a football season, such as fatigue. These insights improve our understanding of how repeated heavy training weeks affects the functioning of football players and acknowledges the possible pitfalls of fatigue and the importance of monitoring players individually to optimize training results.

Keywords: Multidisciplinary, resilience, stressors, thriving, training

The Effect of Heavy Training Weeks on the Psychological and Physiological Development of Professional Football Players

The second leg in the UEFA Champions League round of 16 in 2017 between FC Barcelona and Paris Saint-Germain, later known as La Remontada (The Comeback), is an example of remarkable resilience. PSG won the first leg with an astonishing 4-0, where every goal had a huge effect on the Barcelona team and left them stunned. During the second leg, Barcelona came up 3-0 in the first 50 minutes. They were on course to make their comeback and to go through to the next round. However, PSG scored their away goal in minute 62. Another huge setback that made sure Barcelona needed to score three goals in 30 minutes. However, they bounced back quickly and even thrived under pressure. In the end in this historic and biggest comeback in UEFA Champions League history, Roberto scored the 6-1 in the 95th minute which would seal their victory. In this UEFA Champions League round, Barcelona showed unprecedented resilience by bouncing back from the setbacks and even managed to thrive under pressure, meaning that they even performed better than before.

This example demonstrates that dealing with stressors is an important factor in the performance of professional football players in high-stakes environments. Stressors are omnipresent and cannot be avoided during their careers (Den Hartigh et al., 2022). Although negative effects are usually attributed to stressors (Hill et al., 2018), it is also mentioned to have beneficial effects (Carver, 1998). In the research of Fletcher and Sarkar (2012), for instance, Olympic gold medalists were interviewed about resilience. Most of these athletes mentioned that they would not have won their gold medals if they did not have to overcome certain severe stressors. Given that these severe stressors could generate a beneficial effect on the performance of the athletes, it is reasonable to assume that repeated stressors (e.g. heavy training weeks) can also create favorable outcomes. This would imply that these stressors, big or small, not only could have a detrimental effect on performance but could also increase performance in the long run (Carver, 1998; O'Leary & Ickovitz, 1995). This notion is certainly not new. Marcus Aurelius writes somewhere between 171-175 C.E. the following quote in his Meditations: "Just as nature takes every obstacle, every impediment, and works around it - turns it to its purposes, incorporates it into itself - so, too, a rational being can turn each setback into raw material and use it to achieve its goal" (Hays, 2002, p.108).

The ultimate goal should thus be to not only bounce back but grow or thrive under pressure (Kieffer et al., 2018; Carver, 1998). This research will focus on these possible growth attributes of systematically encountering heavy stressors as well as the possible negative effects. In particular, it explores the effects of heavy training weeks on the psychological and physiological functioning of professional football players to see if they bounce back, thrive or succumb (O'Leary and Ickovics, 1995). To better understand the processes of resilience and stressors, this paper first will elucidate previous research on resilience and the transformation to a dynamic, multidisciplinary construct. Then the multidisciplinary variables used in this study are introduced and conflicting theories on the possible effects of heavy training weeks will be discussed.

Previous Research on Resilience and Thriving in Sports

The topic of resilience within the sports context started to be investigated a few decades ago. Since then, it has had many different definitions (Bryan et al., 2019; Galli & Gonzalez, 2014; Sarkar & Fletcher, 2013). It has been defined as the capacity to withstand stressors (Block & Block, 1980; Block & Kremen, 1996), to bounce back from a stressor (Hill et al., 2018; Fletcher 2019) or to even excel or thrive from a stressor (Carver, 1998; Kiefer et al., 2018; Taleb, 2012).

To be able to research resilience it is necessary to have a common understanding and definition of its concept. As Den Hartigh and Hill (2022) pointed out, the research field of psychological resilience can learn a lot from physics. In physics, the three aforementioned definitions have different terms. The term resilience comes from the Latin verb "resilire" which translates to bounce back.

In the beginning, the capability to bounce back was seen as a stable trait of individuals. This meant that an individual was either resilient or not and that this was stable over time and across domains (Block & Block, 1980). For example, it was measured with a brief questionnaire, composed by Smith and colleagues (2008). It was more in line with withstanding a stressor and its possible negative impact than a process of bouncing back (Fletcher & Sarkar, 2014). Because resilience was seen as a trait and stable (in time and across domains), research depended on methods to examine the determinants of resilience and promoting personal assets to protect an athlete from negative effects in general or at a specific point in time (Fletcher & Sarkar, 2012; Galli & Vealy, 2008). Hence, the notion of resilience was based on a trait like resilience and not on the dynamic process of bouncing back. Due to this trait-like reasoning, research was focused on finding individual differences that would have a positive impact or correlation with resilience as a possibility to enhance it. These are called protective factors and are studied intensely, but usually apart from context, at a single point in time and without the process of resilience in mind (Rutter, 1987; Friborg et al., 2005). Some of these protective factors, motivation and confidence (Fletcher & Sarkar 2012) are still crucial in resilience research today (Hill et al., 2018; Den Hartigh et al., 2022).

Since the article of Hill and colleagues (2018) the complexity and multidisciplinary nature of resilience has been taken into consideration. The definition currently most used and accepted in this field of research is the process of bouncing back to normal functioning after a stressor (Scheffer et al., 2018; Hill et al., 2018).

The Dynamic Process of Resilience and Thriving in Sports

The bouncing-back process has been seen as a key factor of resilience in sports psychology (Fletcher & Sarkar, 2015; Hill et al., 2018; Galli & Vealy, 2008). The whole process is crucial because the state of resilience is not only the immediate response to a stressor, but is also strongly influenced by the state in which it resided before the stressor (Den Hartigh et al., 2016; Fletcher & Sarkar, 2012; Thornton et al., 2019) For example the immediate impact of a stressor could be different depending on the state of the player before the stressors occurred. It is a characteristic of a complex dynamic system and it is called an iterative process or temporal dependency (Den Hartigh et al., 2016, Neumann et al., 2023). The process can be seen from the moment before the impact of the stressor and the bouncing back phase to the normal level of functioning for resilience (Hill et al., 2018; Den Hartigh et al., 2022) or even better functioning called thriving (Carver, 1998). Accordingly, the way of measuring resilience has changed from a single point in time to a time-series design which collects the scores of the variables with a high frequency over a longer period (Araújo et al., 2015; Den Hartigh et al., 2022). Next to the importance of measuring players with a high frequency over a longer period of time, resilience is a multidisciplinary construct. This means that both psychological and physiological variables interact with each other to influence the resilience of a player at a specific point in time. To investigate the psychological and physiological functioning of an individual it is thus necessary to measure multidisciplinary (e.g. psychological and physiological) variables with high frequency over a long period of time. Only then, a comprehensive representation can be constructed of the whole process and the underlying variables.

The Multidisciplinary Measures

The process of a system bouncing back to normal conditions or better ones after a stressor, can be seen across multiple disciplines (Den Hartigh et al., 2022; Scheffer et al., 2018). Consequently, the psychological and sports discipline has shown keen interest in understanding how psychological and physiological variables bounce back to their original functioning after experiencing stressors (Den Hartigh et al., 2022; Gijzel et al., 2017; Hill et al., 2018; Kelmann et al., 2018). Research suggests that psychological variables (confidence), physiological variables (average heart rate), and a combination of both (Rate of Perceived Exertion and recovery) are in constant interaction with each other and the environment (Den Hartigh et al., 2017; Hill et al., 2018, Glazier, 2017). These variables, when measured in a time-series design, show the responses of an athlete to encountered stressors and give an insight into the psychological and physiological functioning of a player and therefore if a player bounced back, thrived, or succumbed from a heavy training week. To create a clear overview, these variables in this paper are structured as stressors measures (RPE and average heart rate) and response to stressors measures (recovery and confidence) to create a clear overview.

Stressors

In addition to the recovery from a significant stressor, which is crucial for the entire process of resilience and thriving, the initial impact of a stressor is also central (Carver, 1998; Fletcher &

Sarkar 2012; Hill et al., 2018). Stressors are categorized based on frequency, intensity, and duration (Den Hartigh et al., 2022). The impact of a stressor can be quantified by internal and external load. External load is about the training load that an athlete needs to do, whereas internal load is about how the body deals with this training load (Brink et al., 2010; Jaspers et al., 2018). The training load will initially result in fatigue due to the energy necessary to complete the training (Luke et al., 2014). Ratings of Perceived Exertion (RPE) is a widespread tool to measure this internal load because it integrates the physiology with the perceived experience of the individual players (Borg, 1982; Brink et al., 2010; Thorpe et al., 2015).

Next to RPE, average heart rate is also a physiological measure to determine the internal load of an athlete (Den Hartigh et al., 2022). Average heart rate is a more objective measure and shows the direct impact of the training session on the athlete. A lower heart rate while performing the same training load, shows a better capacity to handle it (Schneider et al., 2018; Neshitov et al., 2023). In the research of Gijzel and colleagues (2017, 2019, 2020) heart rate was also measured on a daily level. This had significant supplemental extra effects on understanding the resilience of an individual and therefore it is seen as complementary to the other variables measured in this paper.

Response to Stressors

The focus of resilience is on the process from the onset of the stressor to the point of returning to the normal level, or potentially even surpassing it in the case of thriving (Carver 1998; O'Leary and Ickovics, 1995). Recovery from the disturbance to the desired level is crucial in this context. The recovery scores indicate an athlete's assessment of their recovery, reflecting their perception of whether they have sufficiently recovered to perform at their normal capacity (Brink et al., 2010; Knettä & Hassmén, 1998). Where recovery and the process of bouncing back could be seen as closely related, it shows a subjective perspective on the physiological recovery of the players.

Furthermore, a key variable of resilience and performance is confidence (Feltz, 2007; Hays, 2009). Athletes with higher confidence tend to peak under pressure and cope with adversity during competition (Cresswell & Hodge, 2004). Accordingly, it has been used in the literature to elucidate the psychological discipline in the process of resilience (Fletcher & Sarker, 2012; Galli & Vealy 2008; Den Hartigh, 2020).

Overcoming previous heavy stressors is predicted to have a positive effect on confidence and therefore on the psychological and physiological functioning of players (Carver, 1998; Feltz & Öncu, 2014). It can be administered on a high frequency to clearly indicate the process over longer periods. This makes confidence a good variable to investigate the development of the psychological functioning of players in sports (Den Hartigh et al., 2022).

Conflicting Theories on The Effect of Stressors

The research about resilience is mostly focused on predicting injuries and minimizing the possible negative effects of heavy stressors (Brink et al., 2010; Fletcher & Sarkar, 2012). Especially, when multiple stressors follow each other faster than an individual can withstand or recover from (Hill et al., 2018). However, there are more possibilities to happen after encountering a heavy training week (O'Leary and Ickovics, 1995). Therefore, theories for both beneficial and detrimental effects will be clarified and used for the interpretation of the results.

Thriving Through Stressors

A heavy training week can result in a decline initially, but athletes can recover or bounce back to their previous level of functioning or as hypothesized even beyond it (Luke et al., 2014; Schwellnus et al., 2016; Ryan et al., 2014; Carver, 1998; Kieffer et al., 2018; Taleb, 2012). This more beneficial, concurrent effect is called thriving under pressure. It means that players can outperform themself after encountering and overcoming a stressor (O'Leary & Ickovics, 1995; Carver, 1998). Kegelaers and colleagues (2021) revealed that a female basketball team became more resilient and less vulnerable after a high-pressure training intervention, which is in line with positive adaptations of thriving (Carver, 1998).

Carver (1998) claims there are three possible ways an individual can thrive under a stressor. (I) It can decrease reactivity to subsequent stressors, which could be shown by lower RPE scores and average heart rate. (II) It can help the individual bounce back faster than before, which would result in higher recovery scores and confidence levels, and (III) it can improve the overall performance of the individual. These explanations of thriving under pressure fit the dynamic perspective of resilience and can be used to examine the possible effects of repeated controlled heavy training weeks on the psychological and physiological functioning of players.

The decreased reactivity to subsequent stressors is called desensitization: The same stressor that is presented periodically will lose its adverse effect over time. An individual will respond less fiercely to the perturbation and it has a lesser initial negative impact than the first time the stressor is presented. When this impact is recorded longitudinally with RPE and average heart rate, this desensitization can become clear over time (Brink et al., 2010; Carver, 1998; Hill et al., 2018). This decreased reactivity would mean that experiencing heavy subsequent stressors could result in better psychological and physiological functioning and therefore could indicate thriving. Consequently, the possibility arises to investigate suspected improvements due to a lesser impact of repeated exposure to heavy training weeks.

Another possible effect of encountering a previous stressor is a faster return to the previous level. The individual bounces back quicker because he is better at overcoming the disruption than he was before. He has learned from the previous encounter and transfers this newly gathered knowledge when encountering the stressor again (Aldwin et al., 1996; Kolb & Kolb, 2009). A more resilient individual should therefore better recover from encountered stressors in the future and receive a higher recovery score the day after (Brink et al., 2010; Kenttä & Hassmén, 1998).

These possible effects can happen through various mechanisms. Due to overcoming adversity in the past they learned new skills or gained new knowledge which helps them in the future when they encounter the same stressor again (Aldwin et al., 1996; Carver, 1998). It could both enhance dealing with the external or the internal world of the individual (Gross, 1998). Another mechanism for achieving thriving under pressure is through confidence (Carver, 1998; Cresswell & Hodge, 2004). Because players successfully managed heavy stressors before, their belief in their capabilities to overcome subsequent stressors increases. The main processor of confidence is previous success (Feltz & Öncu, 2014). Thus by successfully experiencing heavy training weeks in the past, confidence to overcome subsequent stressors will improve. Because confidence is a key variable to the resilience and thriving of an individual, this could yield beneficial effects for the functioning of the players (Den Hartigh et al., 2022; Feltz, 2007; Feltz & Lirgg, 2001).

As described above, it is important to not solely focus on the disruptive influence of stressors on the level of performance of athletes. Stressors could also have a beneficial effect on performance and could possibly increase the resilience of the individual in the future (O'Leary and Ickovitz, 1995). This perspective of thriving or growing under pressure does not only exist in psychology. Antifragility is the process of growth in the face of stress (Taleb, 2012; Kiefer et al., 2018). It is based on biology and an example could be lent from toxicology and vaccines. Vaccines are small doses of a certain substance (stressor) that trigger a short-term negative response. However, afterward, the system grows stronger and makes the individual immune or more resistant to this disease in the (near)future (Calabrese, 2005a). The question arises if experiencing repeated heavy stressors could also yield these beneficial effects.

Fatigue

In the previous section, arguments are presented as to why experiencing stressors in the past could lead to an increase in the psychological and physiological functioning of players in subsequent stressor conditions. This notion is based on the assumption that the players are not overtrained, have enough time to recover, and are not subjected to excessive demands. Too many or too heavy stressors could potentially harm the functioning of a player (Hill et al., 2018).

For the coaching staff, a big challenge is to design training sessions and intensities to achieve short and long-term training adaptations and maximal performance at the required moments (Mujika et al., 2018). Usually, high-intensity training periods are meant for long-term adaptations while ignoring overtraining and potential negative short-term effects. In the year planning these heavy training periods will ideally be followed by recovery sessions to rest and further exploit the finished heavy training period (Mujika, 1998; Norris & Smith, 2022). If this periodization is done right, the heavy training weeks can be seen as induced heavy stressors which are controlled, meaning that the heavy training week will be accompanied by recovery as well. However, criticism on the busy scheduling in soccer season has accumulated over the past years. The teams in the highest league in the Netherlands play matches in the Eredivisie, KNVB cup, possible European championships or qualifiers, and even extra friendly games. It reflects the necessity to perform almost the whole year round. This incredibly packed schedule is a little less for academy players, but it still could impact the preparedness of the players to train and compete (Luke et al., 2014; Ekstrand et al., 2004; Reilly, 2006; Lago-Penas, 2009). Next to the matches, an academy soccer player at a premier league club in the Netherlands will have practice (i.e. field and/or weight training) six days a week with sometimes multiple sessions on one day. In a study about the cumulative demands of a women's soccer season, fatigue has been shown to accumulate as the season progresses (McFadden et al., 2022). When athletes become more fatigued, it will also increase mental fatigue (Abbott et al., 2020). Thus because of a packed in-season program, there is a possibility that the assumption that players have enough time to recover is violated if the workload is not managed properly during the season. This would mean that the heavy training weeks in the latter part of the season could yield a negative effect on the psychological and physiological functioning of players and make them succumb due to more fatigued players at the end of the season.

Aim of The Present Study

The large amount of research that has been done throughout the decades, is dedicated to the loss of resilience, the possibility for injury prevention, and maintaining the level of performance (Den Hartigh et al., 2022). The principles of thriving under pressure and antifragility, reveal that a stressor could also enhance the resilience of a player (Carver, 1998; Taleb, 2012; Kieffer et al., 2018). However, players must remain fit when encountering these heavy training weeks to make sure fatigue does not result in negative effects (McFadden et al., 2022; Abbott et al., 202). Therefore, the present study aims to explore the possible effects of repeatedly experiencing heavy training weeks on the psychological and physiological functioning of professional football players throughout the 2021-2022 football season.

Method

Participants

In total 15 male academy football players from two youth teams of an Eredivisie football club in the Netherlands were measured during the 2021-2022 season. The players generally have six training days in a heavy training week, with two days of both field and strength training, and a football match. They played in one of the highest leagues possible for their respective ages. Due to confidentiality, potentially identifiable information is not reported in this research.

Design

This research has a longitudinal within-subjects design. When the players signed up for the club, they filled in a written form of consent for participating in research. In addition, specifically for the current study as part of the resilient athletes, players signed an extra informed consent.

The data was obtained in a real-life environment without experimental manipulations or the possibility of shielding for certain external factors. During the season 2021-2022, four different variables have been measured over eleven heavy training weeks. These heavy training weeks are scheduled at fixed points and evenly spread out throughout the season from June to May.

Measures, Materials, and Procedures

For this study, we measured both psychological- (confidence), physiological- (average heart rate), and psychophysiological variables (recovery and Rating of Perceived Exertion). The self-report questions were based on existing literature and were adjusted to the needs of the research context. The Rating of Perceived Exertion (RPE) was obtained on a categorical measurement scale from 6 (very, very light) to 20 (very, very hard) (e.g., Borg 1982; Brink et al., 2010). Average heart rate (except for strength training) was collected with Polar TeamPro (Polar Electro Oy, Kempele, Finland). Recovery scores were obtained on a categorical measurement scale from 6 (very, very poor recovery) to 20 (very, very good recovery) (Brink et al., 2010; Kenttä & Hassmén, 1998). Lastly, Confidence scores were obtained on a Virtual Analogue Scale from 0 (not at all confident) to 100 (very confident) (Bandura, 2006; Mortiz et al., 2000).

The self-report questionnaires were administered on an iPad with an application to make data generation and integration as easy as possible. The measures were taken during the normal daily team routine at training or game days during the 2021-2022 season. The players filled in the self-report items of recovery and confidence on their own in their locker room in the morning before the first training session or match. The average heart rate was recorded during the field training sessions. After a training session or match and within 30 minutes, players filled in the questionnaire with the item about RPE on their own in their locker room.

Data Pre-Processing

Initially, the dataset consisted of 60 male football players from the academy of an Eredivisie club in the Netherlands. However, in this study specific criteria for the selection of participants were employed to ensure that the final sample met the objectives of this research. Therefore, the following criteria were put into place to guide the inclusion of the participants. A player needed to fill in at least five recovery and confidence scores, six RPE scores, and have recorded at least four average heart rates to validate his data during that particular week. Every player needed to have met the inclusion criteria for at least six out of eleven heavy training weeks to join this study. When the requirements were not met and the player did join the study, the values for the variables were noted as missing data. These criteria ensured enough data was collected from the participating players to reveal the development of the recorded variables across the whole season.

Consequently, this results in a sample of 15 male academy football players who fulfill all the requirements and are therefore included in this study. The final data set included the scores recorded for the four variables during the eleven heavy training weeks in the season of 2021-2022. Thereafter, the dataset was split between the different players to be able to see the individual trajectories of the players. Next, the mean scores were calculated for the weeks the players adhered to the requirements. It shows the development of the psychological and physiological variables over the experienced heavy training weeks as a cohort.

In addressing missing data in our research, we employed the Multiple Imputation (MI) method using IBM SPSS Statistics version 28 software. Missing data is a common challenge when conducting longitudinal self-report survey-based research. Multiple Imputation is recognized as a robust technique for handling missing data because it generates multiple plausible imputations based on the present data (Tenan, 2023; Hugue et al., 2018). First, we have analyzed if the missing data was random or based on a pattern. Due to the fact a whole week was excluded when a participant did not fulfill the requirements, a clear pattern was expected and found. In the end, 244 data points were missing in the average weekly dataset (36.97%). Multiple Imputation was executed and the results were pooled. As a final check, we compared the newly created dataset with the original dataset to compare trends and scores over the season. This revealed that the imputed dataset was a precise estimate of the actual data, which underlines the validity of the MI method and ensures a robust basis for the subsequent data analysis.

Data Analysis

A repeated measure ANOVA at the group level has been conducted with the aforementioned variables as within-subjects variables (RPE, average heart rate, recovery, and confidence) to examine how they differ across the measurement moments (heavy training weeks). The results show if the whole model is significant and between what weeks these significant changes occur. This is done by a post hoc pairwise comparison using the Bonferroni correction. It is important to note that larger differences in values might be less significant due to this Bonferroni correction. First, Mauchly's tests revealed that the sphericity assumptions were violated for all variables (in subsequent order: $p=0.004$, $p=0.002$, $p=0.001$, $p=0.046$) and thus the Greenhouse-Geisser test scores are used to test for significance. Then the repeated measures ANOVA is conducted with IBM SPSS version 28 software. This analysis also shows which trends can be spotted in the data and if these are significant.

Results

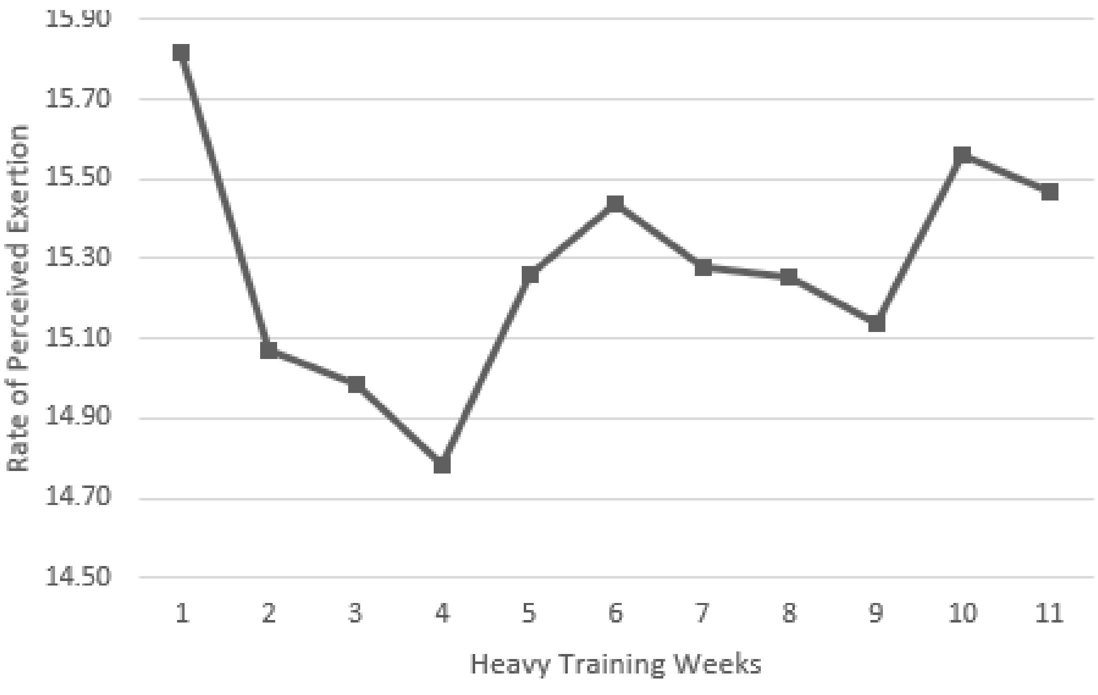
Rate of Perceived Exertion

The repeated-measures ANOVA revealed a significant effect of experiencing heavy training weeks on the initial impact of a training session or match on the athletes ($F(4,495) = 5,754$, $p<0.001$, $\eta^2=0.291$). A post hoc pairwise comparison using the Bonferroni correction showed that significant effects were found between week one and weeks three, four, six, and nine (in subsequent order: $p=0.005$, $p=0.024$, $p=0.26$, $p=0.009$). No other significant effects were found.

The within-subjects contrast test showed a significant quadratic trend ($F(1)=23,667$, $p<0.001$). It revealed that the mean of the initial impact scores followed an *U-curve trend* during the eleven heavy training weeks in the 2021-2022 season, as can be seen in Figure 1.

Figure 1

Marginal Means of Rate of Perceived Exertion Across Heavy Training Weeks



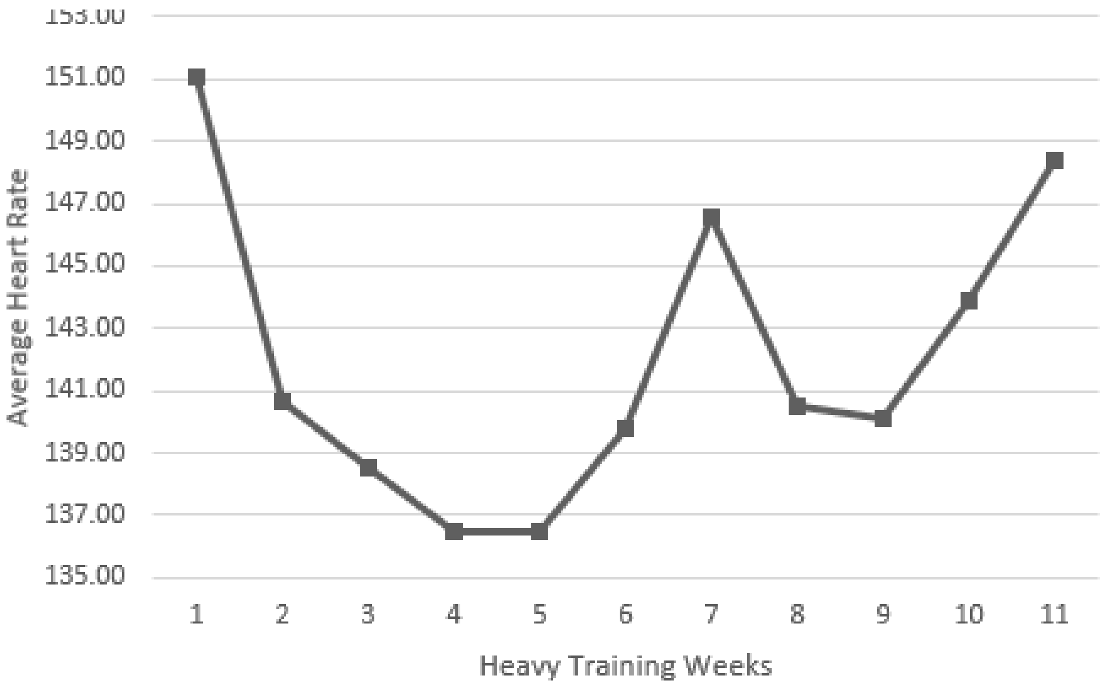
Average Heart Rate

The repeated-measures ANOVA revealed a significant effect of experiencing heavy training weeks on the average heart rate ($F(3,988) = 10,389$, $p<0.001$, $\eta^2=0.426$) A post hoc pairwise comparison using the Bonferroni correction showed that weeks two, three, four, five, six, eight and were significantly lower than week one (in subsequent order: p<00.1, p<001, p=0.001, p=0.24, p<0.001, p=0.35, p=0.32). Week seven was significantly higher than weeks three, four, eight, and nine (In subsequent order: p=0.17, p=0.003, p=0.34, p=0.003).

The within-subjects contrast test showed a significant quadratic trend (F(1)=33,832, p<0.001). It revealed that the average heart rate follows an *U-curve trend* during the eleven heavy training weeks in the 2021-2022 season, which can also be seen in Figure 2.

Figure 2

Marginal Means for Average Heart Rate Across Heavy Training Weeks



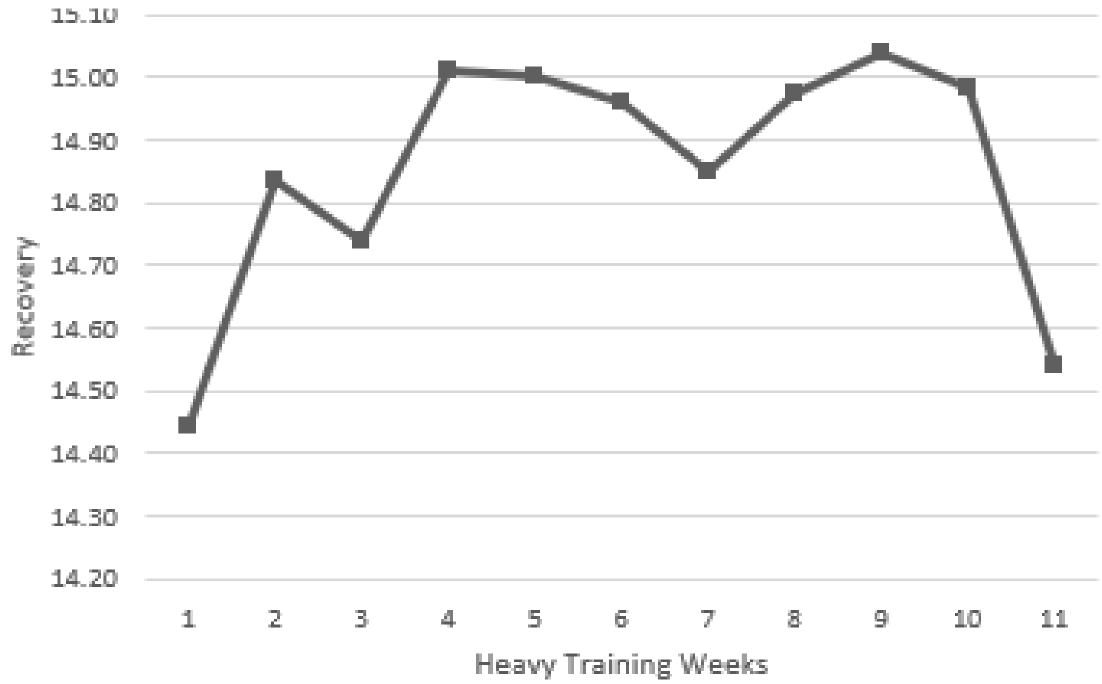
Recovery

The repeated-measures ANOVA revealed a significant effect of experiencing heavy training weeks on the recovery of athletes (F(4,074) = 2,587, p=0.045, η^2=.156). A post hoc pairwise comparison using the Bonferroni correction showed that the only significant effect was that week ten was significantly higher than week one (p=0.001).

The within-subjects contrast test showed a significant quadratic trend (F(1)=22,058, p<0.001). It revealed that the mean recovery scores follow an *inverted U-curve trend* during the eleven heavy training weeks in the 2021-2022 season, as can be seen in Figure 3.

Figure 3

Marginal Means of Recovery Scores Across Heavy Training Weeks



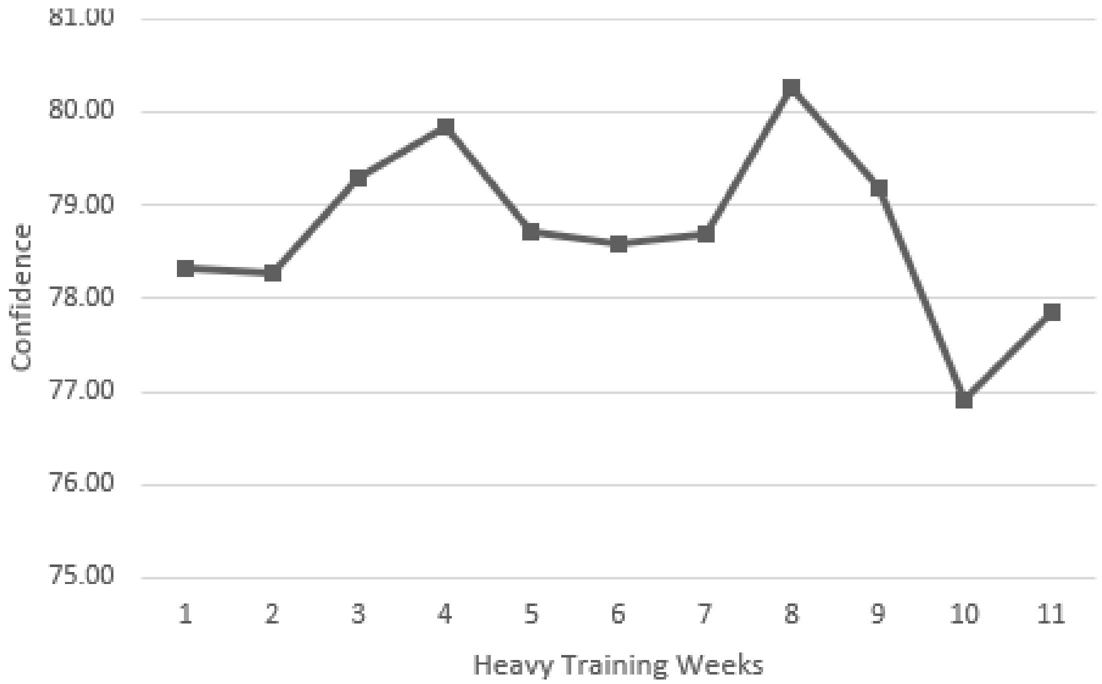
Confidence

The repeated-measures ANOVA revealed a non-significant effect of experiencing heavy training weeks on the level of confidence of the players ($F(4,618) = .470$, $p=0.784$, $\eta^2=.032$) A post hoc pairwise comparison using the Bonferroni correction revealed no significant effects.

The within-subjects contrast test showed no significant trends during the eleven heavy training weeks in the 2021-2022 season, as can be seen in Figure 4.

Figure 4

Marginal Means of Confidence Levels Across Heavy Training Weeks



Discussion

In the present study, we examined the possible effects of experiencing and overcoming repeated controlled heavy training weeks on psychological and physiological functioning. We investigated the effects through four different variables over one season: Rate of Perceived Exertion, average heart rate, recovery, and confidence.

First, the results of the separate variables will be discussed in detail, starting with the stressor measures (RPE and average heart rate) and then the response to stressor measures (recovery and confidence). Afterward, we will combine the patterns to form the overall conclusion.

Rate of Perceived Exertion

The initial negative impact of the controlled heavy stressors, measured by RPE, showed a significant effect over time. RPE decreased over the first half of the season. This decrease supports the idea that experiencing and overcoming these heavy training weeks can improve the psychological and physiological functioning of players (Carver, 1998, Fletcher & Sarkar, 2012; Kieffer et al., 2018). Additionally, a smaller initial negative impact supports the desensitization argument of thriving from

Carver (1998). However, a significant and strong trend analysis reveals that the initial effect will be reversed halfway through the season and follows an *U-curve.* This means that the heavy training weeks start having negative effects on the rate of perceived exertion of players and fatigue might start to play a bigger role (McFadden, 2022; Abbott et al., 2020; Meeusen et al., 2013).

Average heart rate

Average heart rate showed multiple significant effects, where the heart rate decreased in the first half of the season, it increased during the latter half. It revealed that both positive and negative effects could take place, depending on the circumstances. A lower heart rate, given the same training load, portrays an improvement in the physiology of an athlete (Schneider et al., 2018; Neshitov et al., 2023). A lower average heart rate supports the desensitization argument of Carver (1998) because the impact of the training session is better handled by the player.

On the other hand, the trajectory changed halfway through the season. This transition to adverse effects over the latter half of the season could again advocate for a possible effect of fatigue at the end of the season (McFadden et al., 2022; Abbott et al., 2020; Meeusen et al., 2013).

Recovery

The recovery scores of the athletes did change significantly. This significant effect only arose between weeks one and ten, which indeed shows a positive effect on recovery over time. It shows that encountering and overcoming heavy training weeks could increase the perceived recovery of the players (Carver, 1998; Kieffer et al., 2018; Taleb, 2012). Therefore heavy training weeks have the potential for the development of athletes.

An important side note we made was that the athletes should be fit and have enough time to recover during these training periods. A trend analysis again showed a significant *inverted-U trend* during the season in contrast with the trend of RPE. This entails that at first, the recovery scores improved until a specific point in time, where the scores started to show a decline in recovery. While multiple factors could play a part in the changing trend, it does suggest that there is a certain point in time during the season, when the heavy training weeks start to harm the recovery of the athletes. As argued before, this could be the case because the players are more fatigued at the end of the season (McFadden et al., 2022; Abbott et al., 2020; Meeusen et al., 2013).

Confidence

We did not find any significant effects, positive or negative, of experiencing and overcoming heavy training weeks on confidence. Next to this, no significant trends could be observed as well. Previous success plays a big part in the confidence to achieve the same success when presented with the same stressor again (Feltz & Öncu, 2014; Carver 1998). This would suggest higher scores of confidence during the later heavy training weeks. However, the results did not support this claim.

While we might have suspected an increase in confidence based on Carver's framework (1998) and the term antifragility (Kieffer et al., 2018; Taleb, 2012), specifically regarding overcoming repeated controlled heavy stressors, this was not the case. The self-report question that was administered read: "How confident are you that you can perform maximally today?" It does not specifically ask about dealing with the heavy training session, but over performance in general. Therefore, confidence about dealing with heavy training sessions might have increased, but confidence about other aspects could be much different. Confidence is a broad subject and it can depend on many different factors (e.g. peer interaction (Hwang et al., 2017) and positive momentum (Den Hartigh et al., 2014). Hays and colleagues (2009) found six higher-order themes for debilitating confidence; poor performances, injury/illness, poor preparation, coaching, pressure and expectations, and psychological factors. Each of these factors and more could influence the confidence of a player at a certain point in time. Because the present paper is an observational study without manipulations or the possibility of controlling for the other variables, the possible positive effect of experiencing and overcoming previous repeated controlled heavy stressors on confidence could be deduced by confounding variables

At the beginning of the season, both RPE and average heart rate decreases with heavy training weeks experienced. This indicates that the players handle the internal load better and is in line with the desensitization argument of Carver (1998). Furthermore, the recovery scores increased in the first half as well. The players are bouncing back quicker when looking at fitness, and therefore this could yield beneficial effects. The combination of decreases in internal load measures and increases in recovery scores shows the possibility of thriving and improving under stressful circumstances (Kieffer et al., 2018; Taleb, 2012). However, these beneficial effects become negative in the second part of the season. The internal load increases and it takes longer to recover to the same levels as before. Because these effects are found in objective (e.g. average heart rate) as subjective measures (e.g. RPE and recovery) it shows a robust change over time which could be explained by fatigue (McFadden et al., 2022; Abbott et al., 2020; Meeusen et al., 2013). These results could indicate a very delicate boundary between the possible beneficial effects of controlled heavy stressors and when the stressors are becoming too much. It combines the possibilities of thriving under pressure (Carver, 1998; Fletcher & Sarkar, 2012), antifragility or growth under stress from Biology (Taleb, 2012; Kieffer et al., 2018) with the possible negative effects of performance losses and fatigue at the end of the season (Den Hartigh, 2022; McFadden et al., 2022; Abbott et al., 2020).

Limitations & Strengths

While the present study contributes to the ever-growing body of literature about the effects of stressors on athletes, it is also important to acknowledge its limitations and strengths. Each research endeavor has potential sources of bias and constraints, and certain strengths, and this study is no exception. Therefore we will outline the key limitations and strengths.

The first limitation of the present study is missing data. Due to strict inclusion criteria and practical challenges, fewer participants than foreseen were viable. These strict inclusion criteria were necessary to make sure the heavy training weeks were actually perceived as heavy training weeks and that we had enough data for data analysis. We consequently used a Multiple Imputation model to impute 36,97% of the week's average scores. This method, however, ensures that the missing data has a minimal impact on the data analysis.

The present study has been done as part of an already present daily routine. This meant that the questionnaires were filled in at fixed moments without disrupting the day of the players. The observational nature of the research enhances the external validity. It reflects the complexity of realistic situations and provides insights into how the results can be translated and applied in authentic settings. In an environment like a football academy, there will always be many different factors at play. Therefore this is the best way to gain these insights over a longer time. Nonetheless, the observational nature of the study also meant that we did not have the opportunity to apply experimental manipulations or control over various extraneous variables. The non-significant effect of the increase in confidence could possibly be explained by confounding variables. For example, poor performance or positive momentum could have an impact on confidence levels (Den Hartigh et al., 2014; Hays et al., 2009). When all confounding variables could be controlled for, an improvement in confidence due to experiencing and overcoming heavy training weeks might reveal itself.

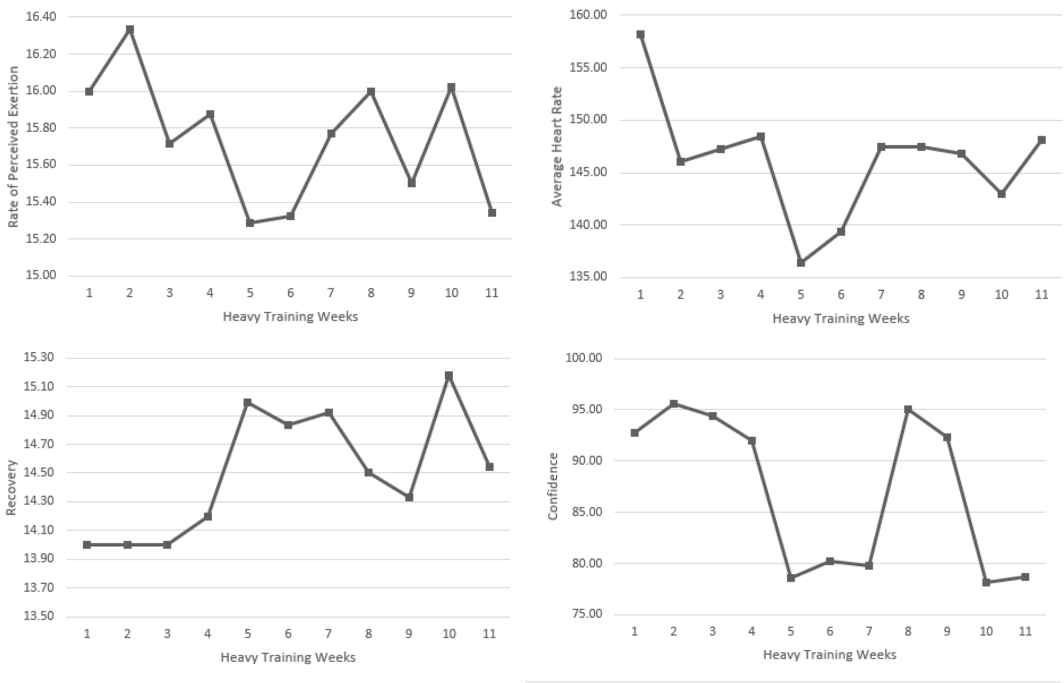
Another limitation of the present research is the fact the Bonferroni correction was used for the analysis of the repeated measures ANOVA. This correction controls the familywise error rate. This reduces the risk of Type 1 errors but it also increases the occurrence of Type II errors. This means statistical significance may be undetected because of the stringent correction. This in combination with a small sample size, might result in not enough power to detect true differences. Therefore some bigger differences in values, might not be presented as significant.

A final limitation is the ergodicity assumptions of generalizing data from individual trajectories to mean group scores. Because developmental trajectories are unique, it does not necessarily generalize to other players (Hill et al., 2021; Neumann et al., 2021). In this research, we begin to explore the possible effects of repeated controlled heavy stressors on the psychological and physiological functioning of professional football players over a longer period. Therefore we combined the data of the participants to generate a general overview, and it is important to note that this might not reflect the trajectories of individual players. All individual trajectories are added in Appendix A.

Most players show trajectories somewhat related to the generalized development as discussed above. To illuminate that discrepancies between the trajectories are prevalent, one player will be highlighted here, see Figure 5.

This player shows counterintuitive trajectories for both RPE and recovery. His RPE and recovery scores kept improving throughout the whole season. The expected turning point did not occur for these variables. However, the average heart rate does show an equivalent trajectory to the expected curve. So objectively the physiological side starts to decrease a little, while the subjective view on it, RPE, still reports improvements. These differences highlight the importance of monitoring individual trajectories.

Figure 5
Player 8: The Marginal Means Scores of All Variables Across Heavy Training Weeks



Future research directions

This research adds to the preexisting knowledge and literature about the effect of encountering and overcoming stressors on a professional football player, both psychological and physiological. It reflects an exploration of the possible effects of stressors instead of focusing on the negative results they can elicit. Where it sheds light on the trends of psychological and physiological components of resilience and thriving during a soccer season, it also raises other interesting research questions.

Firstly, we expected that confidence would increase over time when an athlete encountered and overcame repeated controlled heavy stressors (Carver, 1998; Feltz & Öncu, 2012). Nonetheless, this research showed no significant effects which, already mentioned above, might be because of confounding variables. Therefore, an experimental design might be beneficial to see if confidence will increase if other variables (e.g. previous performance (Den Hartigh., 2014; Hays, 2009)) are indeed controlled for. It might contradict our findings or there might be other things at play we are not aware of at this point.

Another interesting future research venture would be to investigate if the trends we found for recovery scores, RPE, and average heart rate could be replicated. If this trend can be found over multiple seasons, this means it is a repetitive and stable phenomenon and future research is necessary to see what the precise nature of this trend is and by extension how to prevent the negative effects from happening.

Practical Implications

This research shows that heavy repeated stressors can be beneficial for athletes, but it also implicates the fact that fatigue might play a bigger role at the end of the season ((McFadden, 2022; Abbott et al., 2020; Meeusen et al., 2013). Mujika and colleagues (2018) argue that some training over the summer period could increase preparedness at the start of the season (Mujika, 2003). It also showcases the possible need for an integrated, multifactorial approach to periodization to minimize the adverse effects at the end of the season (Mujika et al., 2018).

Because fatigue increases over the season, it is easy to assume that the training load needs to be decreased at the end of the season. However, heavy training weeks can be categorized as heavy through multiple facets of training. Modric and colleagues (2021) show that players are even under-trained in high-intensity running, while training loads must relate to match loads (Scott et al., 2014). Therefore it is advised not to suddenly lower the training load, but to look into the training distribution across the week. For example, a higher training load three days before the match had a positive correlation with games won (Modric et al., 2021).

While the suggestions above highlight the importance of managing the possible negative effects found in our study, it is also crucial to look at the positive. This research shows that encountering and overcoming stressors can increase the psychological and physiological variables of players. This is also in line with the research on the positive effects of planned disruptions (Sarkar & Fletcher, 2017; Kegelaers et al., 2019). In practice, this would entail more changes in training demands and load, applicable to the preferred outcome.

For all practical implications mentioned above it is important to monitor individual trajectories and scores. These vary and therefore the same intervention could have both beneficial or detrimental effects depending on the individual.

Conclusion

The present study shows that heavy training weeks initially have a beneficial effect on the psychological and physiological functioning of professional football players. However, these effects seem to diminish and even become detrimental in the second half of the season. To be more specific, it shows that players can better recover from subsequent heavy training weeks, that these sessions have a lesser negative impact straight afterward and even average heart rate does decrease in the first half of the season. No significant effects or trends are found for confidence. In the second part of the season, the effects become negative: recovery takes longer, the initial effect of a training session increases and the average heart rate increases as well. Fatigue in the latter half of the season could be the cause of the detrimental effects. Therefore, the present study shows the possible beneficial effects of heavy training weeks on the psychological and physiological functioning of professional football players but also outlines the possible challenges that can arise at the end of a football season. However, these results represent mean group scores. Individual trajectories can look different, which is why we propose an individual approach when monitoring the effects of heavy training weeks on professional football players.

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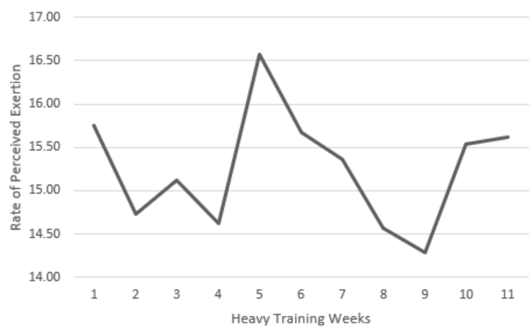
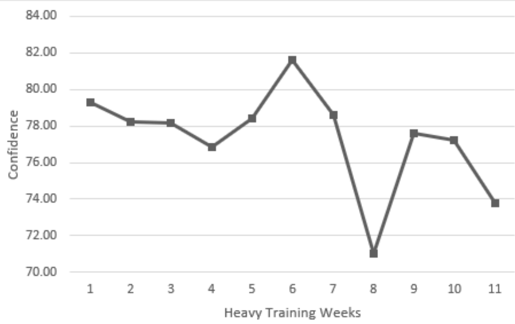
Appendix A

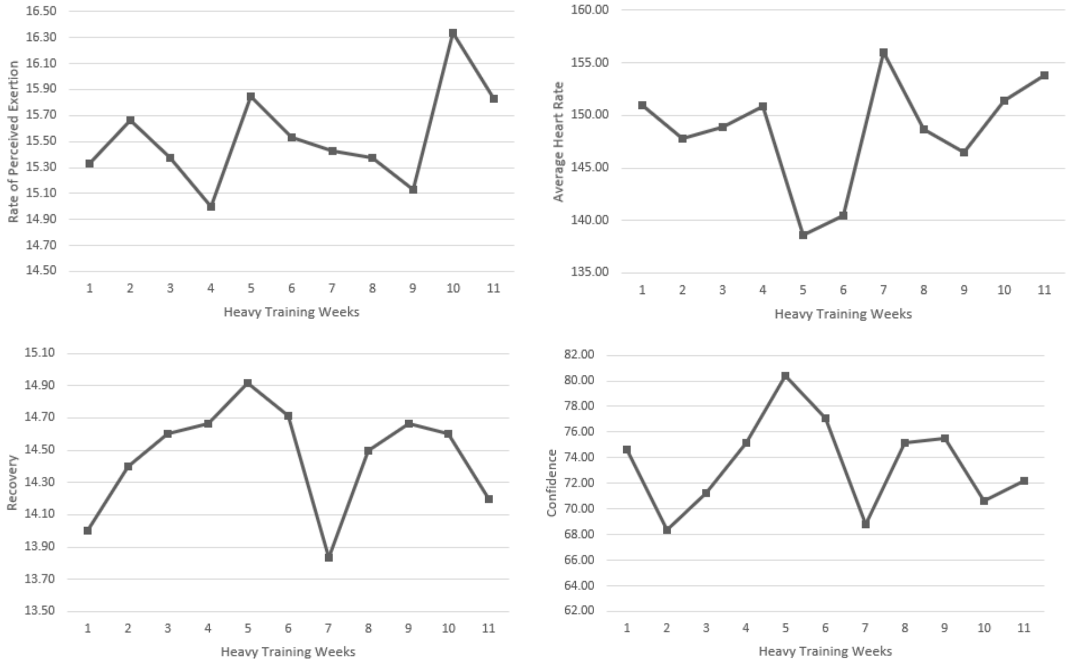
Player 1



Player 2



Player 3



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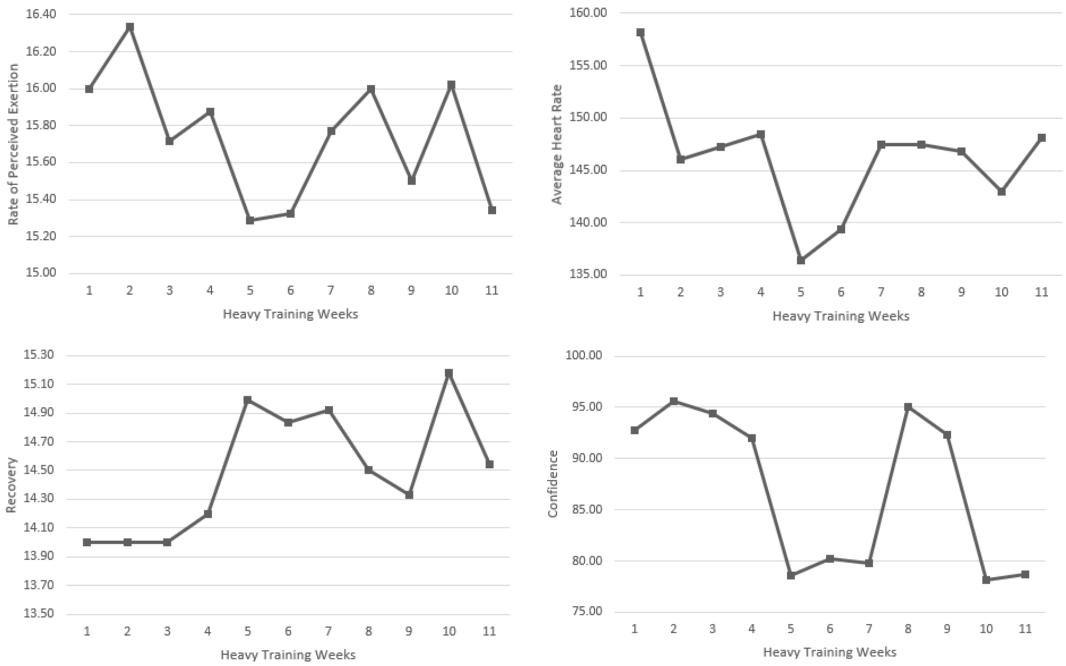

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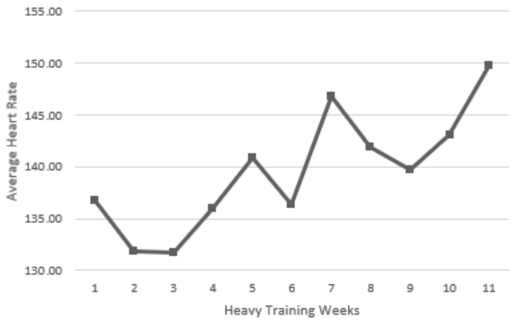

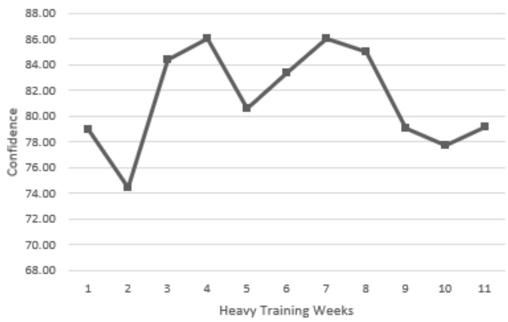

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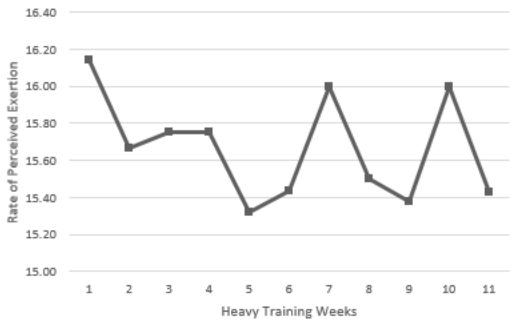
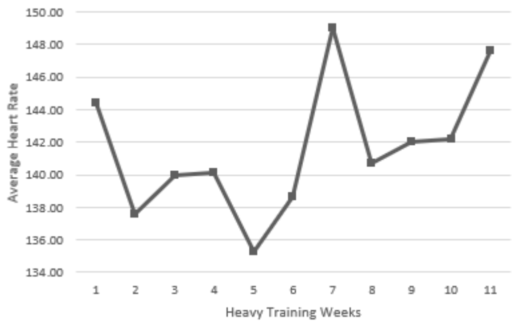
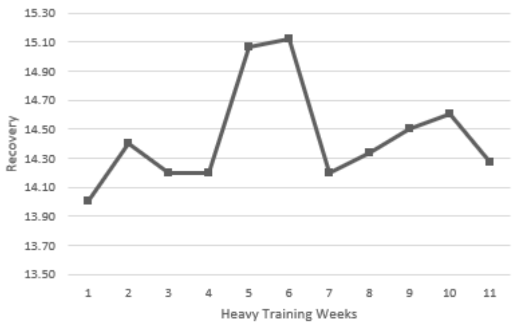
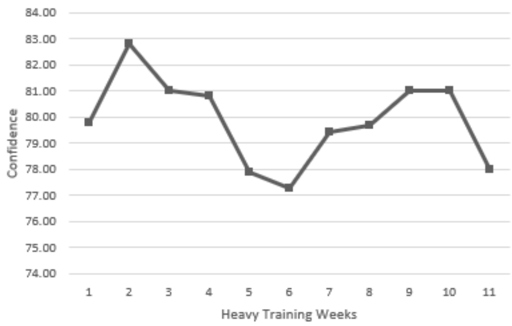
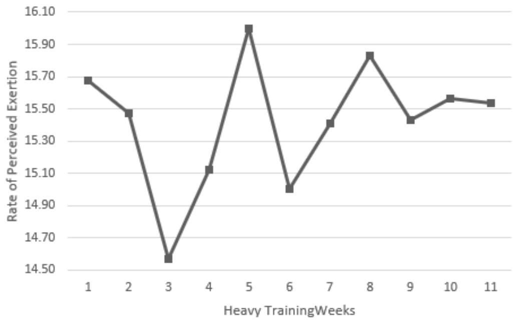


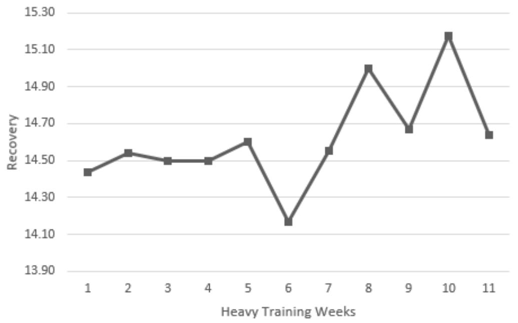






Player 7





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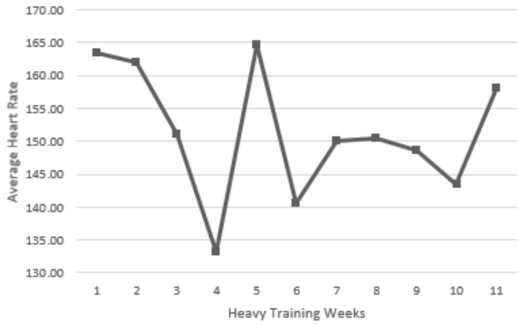

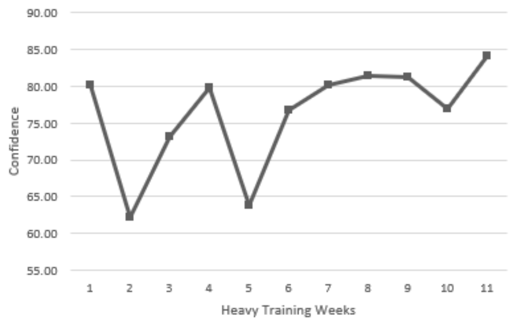

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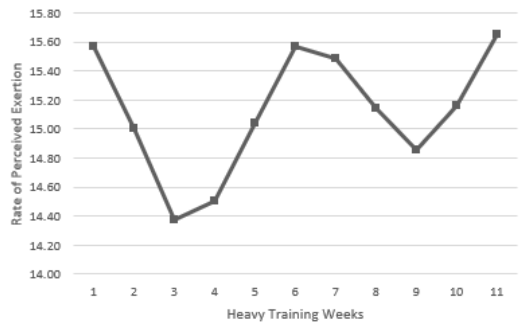
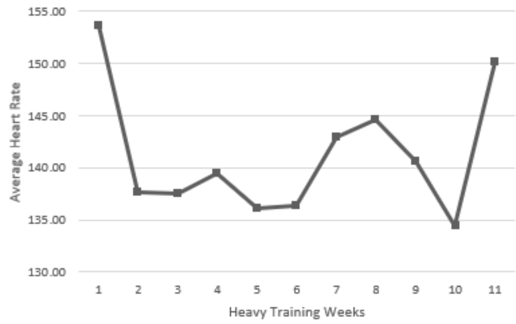
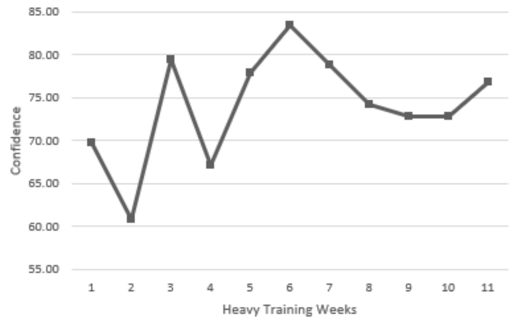
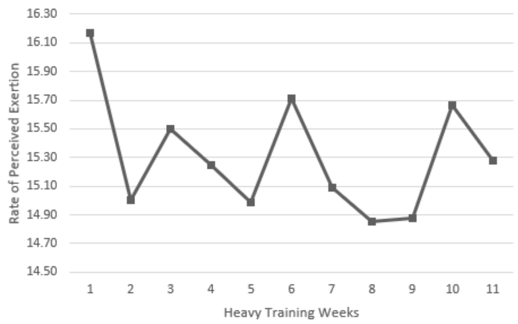
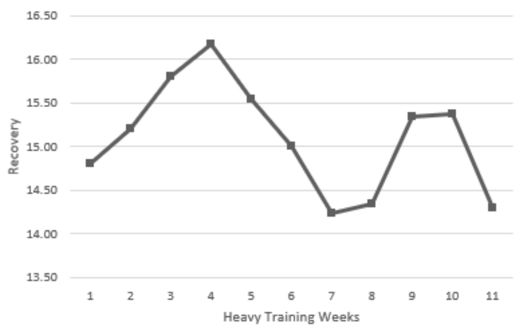


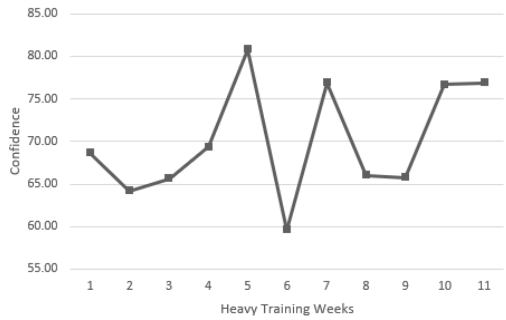




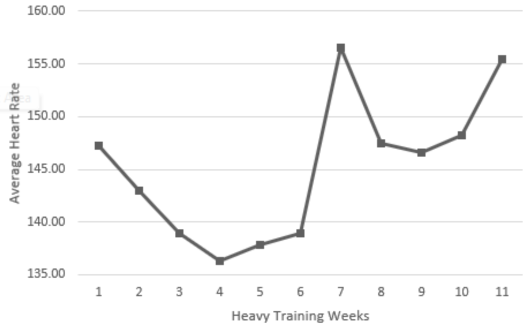
Player 10

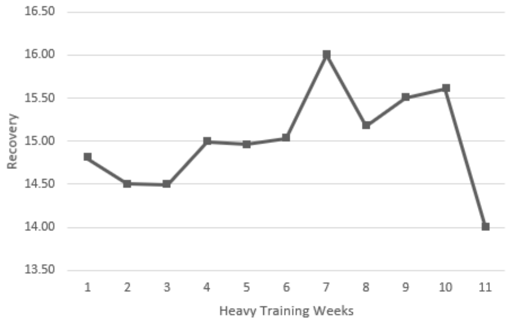


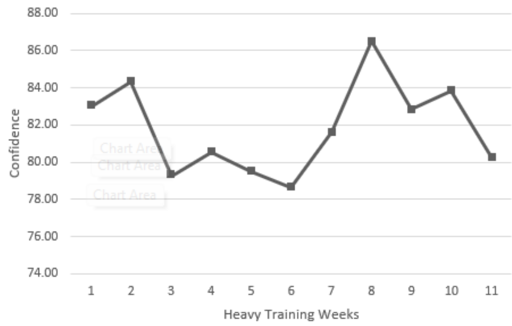




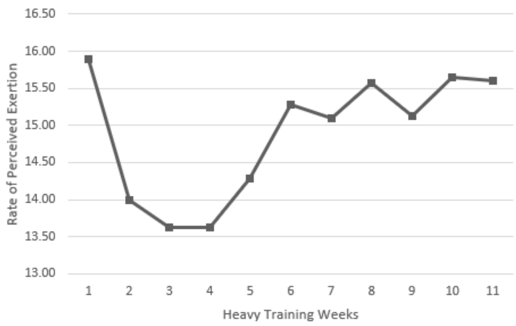
Player 11

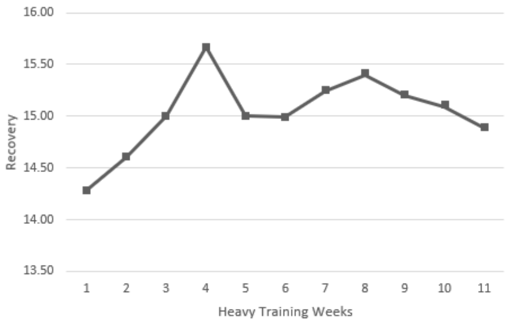




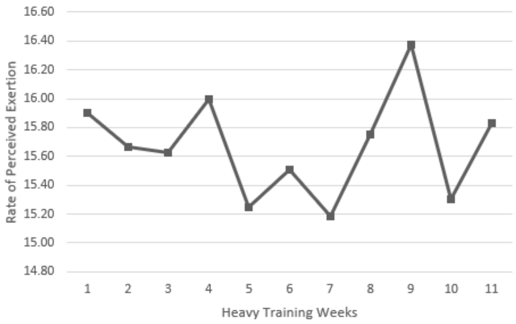


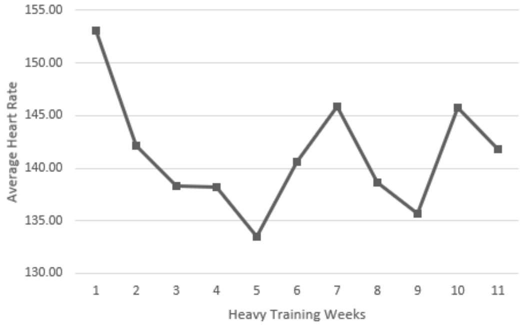
Player 12

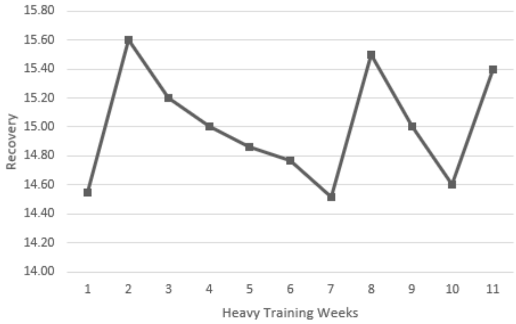




Player 13







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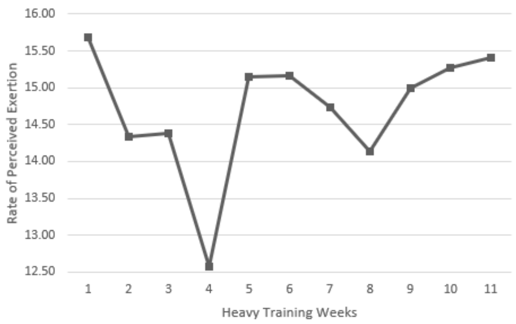
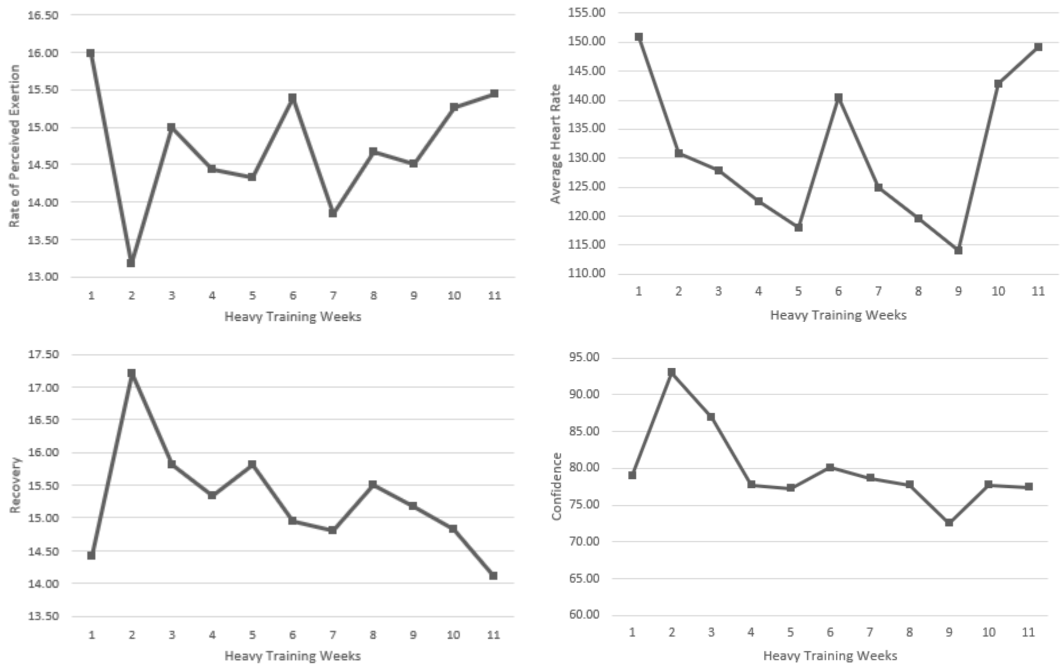


Player 15


Rate of Perceived Exertion
16.50
16.00
15.50
15.00
14.50
14.00
13.50
13.00
1 2 3 4 5 6 7 8 9 10 11
Heavy Training Weeks
Average Heart Rate
155.00
150.00
145.00
140.00
135.00
130.00
125.00
120.00
115.00
110.00
1 2 3 4 5 6 7 8 9 10 11
Heavy Training Weeks
Recovery
17.50
17.00
16.50
16.00
15.50
15.00
14.50
14.00
13.50
1 2 3 4 5 6 7 8 9 10 11
Heavy Training Weeks
Confidence
95.00
90.00
85.00
80.00
75.00
70.00
65.00
60.00
1 2 3 4 5 6 7 8 9 10 11
Heavy Training Weeks