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Audinga Kniubaitė

MODELING OF COACHING IN HIGH-PERFORMANCE FEMALE HANDBALL PLAYERS

Summary of the Doctoral Dissertation
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CONTENT

INTRODUCTION

Athlete coaching is multidimensional process (Lambert & Mujika, 2013; Buchheit, 2014; Mattocks et al., 2016; Bourdon et al., 2017; Buckner et al., 2017; Conte, Kolb, Scanlan, & Santolamazza, 2018; Kenneally, Casado, & Santos-Concejero, 2018; Michalsik, 2018; Bompa & Buzzichelli, 2019; Laursen & Buchheit, 2019; Skarbalius, Vidūnaitė, Kniubaitė, Rėklaitienė, & Simanavičius, 2019), inseparably requiring the application of general technological principles of system management (Adams, 1971; Schmidt, 1975), coaching modelling and control (Banister, Calvert, Savage, & Bach, 1975; Banister, 1991; Halson, 2014; Bourdon et al., 2017; Buchner et al., 2017; Cardinale & Varley, 2017; Coutts et al., 2017; Cunanan et al., 2017; Kellmann, Bertollo, Bosquet, Brink, Coutts, Duffield & Kallus, 2017; McGuigan, 2017). Sports business product developers are constantly increasing the number of competitions and extending the duration of competitions (Mujika et al., 2018; Laursen & Buchheit, 2019). This inevitably poses problems of how to prepare athletes for competitions in a short period of time. Usually, elite handball players prepare for the season during the six weeks of the preparation period (Michalsik, 2015). However, research still has not revealed if a training program of similar duration could ensure the preparation of high-performance female handball players for the sports season. Another problem is how to maintain handball players' sport performance during the nearly 10-month competition period because the deterioration of the players' biomotor abilities also leads to the inevitable processes of *detraining*, which is the decreasing sport performance (Mujika & Padilla, 2000; Mujika & Busso, 2008; Mujika, 2017; Mujika et al., 2018). For this reason, *retraining* programs are applied to recover sport performance (Gabbet et al., 2017; Bourdon et al., 2017). The ongoing detraining processes raise two other problems: 1) when and what retraining models to apply in order to retrain sport performance; 2) what models of detraining and retraining and their changes would allow athletes to achieve the highest level of sport performance several or even ten more times a season (Mujika & Padilla, 2000; Mujika & Busso, 2008; Mujika, 2017; Mujika et al., 2018). Such complex problems of athlete coaching can be solved only by applying the complex management of athlete coaching (Cunanan et al., 2018). Although sports science researchers (Grandou, Wallace, Impellizzeri, Allen, & Coutts, 2019) present complex models

of athlete coaching management, they still usually study only narrow aspects of athlete coaching monitoring. This allows managing athlete coaching only in part – some one-sided aspects of sport performance (Abade, Abrantes, Ibáñez, & Sampaio, 2014). Therefore, only a systematic approach to athlete coaching, only the systematic management of athlete coaching can ensure their targeted coaching (Araújo & Davids, 2016). *However, systematic management of coaching of high-performance female handball players has not been developed yet.*

Effective coaching of athletes is characterized by elements of *sport performance* and *training* (Gabbett et al., 2017; Lazarus et al., 2017) that interact according to the principle of a closed loop control system (Schmidt, 1975). If specific sport performance is given priority, it is likely that specific training will predominate in the coaching of athletes as well. Attitudes are not the same for both sport performance and training. Researchers (Hoff & Helgerud, 2004; Laursen & Buchheit, 2019) believe that the three types of sport performance – athletic, technical and tactical – are the most significant, others (Bangsbo, 1994; Skarbalius, 2003) emphasize theoretical preparation as well. Such different philosophies describing the sport performance of handball players also define different philosophies of their coaching. Hoff and Helgerud (2004) maintain that athletic, technical and tactical training should take one thirds each in coaching and they do not separate theoretical, integral and psychological training in percentage terms. Bangsbo (1994), Skarbalius (2003) also do not single out psychological training. Researchers (Bresciani et al., 2010; González, Coronado, & Rosa, 2013) suggest that psychological training is carried out in conjunction with other types of training, and in particular with high-intensity physical activity, especially during the preparation period. However, athlete coaching requires a comprehensive training program that covers all types of training (Clemente, Nikolaidis, Guijarro, Martins, & González-Víllora, 2017; Skarbalius et al., 2019). For this reason, Skarbalius and co-authors (2019) argue that it is necessary to distinguish not only all types of training, but also the time devoted to warming up and recovery. *However, the current research has not yet developed a model for the percentage structure of elite handball players' training types in a sports season.*

The problem of periodization of the sports season. After extending the period of competitions of Lithuanian high-performance female handball players to nine months, also when it is necessary to

achieve the highest level sport performance at the beginning, middle and especially at the end of the season, during the final stage of the Lithuanian Championship, it becomes problematic and unacceptable to apply the principles of both classical (Matveyev, 1964) and block (Issurin, 2008, 2010, 2014, 2016; Mattocks et al., 2016) periodization. The problem is how to integrate the principles of one and the other periodization in general (Kenneally et al., 2018; Manchado et al., 2018; Mujika et al., 2018) and how to implement this by developing a season coaching model for high-performance female handball players. The problem is how player loads and content should change depending on the periodization, and what coaching concepts (consistent training, concentrated training, simultaneous effect, conjugate training) should prevail (Bresciani et al., 2010; Rosenblatt, 2014). *The coaching model of sports season periodization for elite female handball players has not been grounded by research yet.*

External and internal loads in workouts. For two decades now, a new technological trend in athlete coaching has been introduced in the assessment of external and internal load indicators (Bartlett, O'Connor, Pitchford, Torres-Ronda & Robertson, 2017; Castillo, Weston, McLaren, Cámara, & Yanci, 2017; McLaren et al., 2018; Impellizzeri et al., 2019; Bredt, Chagas, Peixoto, Menzel & de Andrade, 2020). The external loads of elite handball players are characterized by the characteristics of player loads (distance covered, movement at different speeds, movement on different axes), and different intensities (Luteberget & Spencer, 2017; Wik, Luteberget, & Spencer, 2017; Luteberget, Trollerud, & Spencer, 2018). Studies of internal loads of high-performance handball players were also performed (Manchado et al., 2013a; Michalsik, Aagaard, & Madsen, 2013; Belka, Hulka, Safar, Weisser, & Samcova, 2014; Michalsik, Madsen, & Aagaard, 2014; Michalsik, 2015, 2017, 2018) describing objective (intensity zones in terms of heart rate per minute) and subjective (perceived exertion method – RPE) evaluation criteria. The subjective method of RPE is especially relevant (Borg $_{0–10}$). Studies (Foster, 1998; Foster et al., 2001) have established it as a valid and reliable method. This is especially relevant because research has shown that when performing the same external loads, athletes and coaches evaluate their impact on athletes' internal loads differently (Foster, Rodriguez-Marroyo, & De Koning, 2017). Both specific (playing official and control matches, improving technical and tactical skills) and non-specific loads (developing general strength, endurance) are used when coaching female handball players.

In order to optimize the coaching program, it is important to determine what external and internal loads are performed by high-performance female handball players during matches and how they differ from other loads applied. *Research has not yet identified the values of external and internal load indicators of elite female handball players' practise sessions, which would create preconditions not only to optimize the coaching of the handball players' teams, but also to individualize loads according to the players' positions.*

Management of coaching modeling for female handball players. Accidental examination of the characteristics of sport performance or coaching of individual female handball players remains only as an indicator value describing those characteristics (Van den Tillaar & Ettema, 2004; Ronglan, Raastad, & Børgesen, 2006; Thorlund, Michalsik, Madsen, & Aagaard, 2008; Haugen, Tønnessen, & Seiler, 2016; Bourdon et al., 2017; Ferragut, Vila, Abraldes, & Manchado, 2018; Wagner et al., 2019; Vila, Zapardiel, & Ferragut, 2020; Wagner, Fuchs, & Michalsik, 2020).

Research relevance. The sport performance of a handball team is determined by a number of factors, the effects of which are quite different and many of the factors have not been scientifically studied yet. The performance of female handball players has even less been studied. Moreover, the peculiarities of the effect of different factors on high-performance female handball players have not been studied.

The research problem of the dissertation was to determine the essential criteria of team sport performance management: training loads and the athlete's response to the training load, which would allow for effective modeling and development of optimal coaching programs.

It is relevant to model and manage the coaching process based on those criteria so that the sports results are achieved in a timely manner. The problem questions arise as to what criteria (Kelly & Coutts, 2007; Coutts et al., 2017; Wik et al., 2017; Hermassi et al., 2018; Skarbalius et al., 2019) could be used to model the coaching of high-performance female handball players and what criteria would facilitate managing coaching. *The analysis of the research problem allows to raise a hypothetical assumption that only a complex and systematic approach would allow to manage the coaching of high-performance female handball players' during sports season.*

Research problem: how to model the coaching of high-performance female handball players to maintain sport performance during the competition period for nine months?

Research hypothesis: integral periodization, based on the principles of classical and block periodization, external and internal indicators of specific and non-specific training loads applied allow for effective modeling and management of season coaching for high-performance female handball players.

Research object: management and modeling of high-performance female handball players' coaching.

Research aim: to develop a coaching model for the annual cycle of high-performance female handball players and to set the management criteria.

Objectives:

1. To develop a periodization model of season coaching for high-performance female handball players.
2. To describe the external and internal loads of high-performance female handball matches and practice sessions with different content.
3. To establish coaching modeling management criteria.
4. To reveal the peculiarities of sports and academic activities of high-performance female handball players.

The study is based on the following theoretical provisions:

Athlete coaching is an educational process that creates wide spaces for personal development, motivation and pursuit of a dual social career (Moreno & Cervello, 2005; Šukys, 2005; Malinauskas, 2007, 2008; Vella et al., 2013; Romar et al., 2016; Henry, 2013; Ryba et al., 2017; Brustio et al., 2020; Harrison et al., 2020).

Effective management of athlete coaching is based on the principle of a closed loop control system and the monitoring of the relationship between coaching and sport performance models (Perl, 2001; Busso & Thomas, 2006; McGarry et al., 2013; Cunanan et al., 2018; Mujika et al., 2018).

Modeling of detraining and retraining. During a long period of competitions, changes in athlete detraining and retraining are affected by modeling of the content of training loads based on one- and two-factor theories (Mujika & Padilla, 2000; Mujika & Busso, 2008; Mujika, 2017; Mujika et al., 2018).

Classical and block periodization training of athletes. The integrated application of the classical and block periodization model allows athletes to achieve the highest sport performance several times in one season (Matveyev, 1964; Issurin, 2008, 2016; Mattocks et al., 2016; Mujika et al., 2018).

Scientific novelty of the dissertation. Based on the principles of classical and block periodization, a coaching model for high-performance female handball sports season was developed, the optimal values of block duration, training loads and content indicators were determined, the sequence of different practice loads to slow down the detraining process or retrain deteriorated sport performance was established. Model values of external (movement) and internal (intensity) load indices of different types for high-performance female handball players of different positions were developed. The values of external and internal load indicators of matches and control matches were established for warming up, the first and second halves. Criteria for high-performance female handball team season management (periodization elements, training loads and content, nature of exercises, external and internal indicators of loads) were established.

Limitations. Due to the limited number of subjects in the target group, an experiment of one alternative was performed and without comparing the research indices with those in the control group, it is not possible to assess the effect of the coaching program on changes in sport performance.

Further research. Using valid and reliable recording CATAPULT equipment, to study the peculiarities of the relationship of external and internal loads including specific exercises applied in different practice sessions, which would allow individualization of loads for players and create preconditions for more efficient management of handball coaching process.

Practical significance of the dissertation. Based on the principles of classical periodization, it is recommended to model the season coaching program in blocks. The developed high-performance female handball coaching model for the sports season will be able to be used not only by teams of the same skill level, but, based on the principles of the model structure, coaches will be able to prepare a coaching program for teams of different mastership or ages. The target model characteristics of microcycles, block contents and load volume were determined. The presented model of changes of the seven loads (matches, control matches, integral training, pre-competition, technical-tactical, strength, endurance) during the whole season will allow coaches to practically manage the processes of players' detraining and retraining. The identified characteristics of external and internal loads of players in different positions will allow individualization of training loads for players.

1. THEORETICAL ASSUMPTIONS OF ATHLETE COACHING MODELING

Sports researchers suggest that only a planned and managed process of coaching athletes creates favourable conditions for them to achieve the best results (Busso & Thomas, 2006; Mujika & Busso, 2008; Thorpe et al., 2016; Coutts et al., 2017; McGuigan, 2017; Manchado et al., 2018; Michalsik, 2018; Bompa & Buzzichelli, 2019; Impellizzeri et al., 2019; Mujika et al., 2018; Skarbalius et al., 2019) in the most important matches. Management includes predicting results, modeling match performance indicators, creation and execution of the match key indicators, and adjustment of sports training (Lambert & Mujika, 2013; Buchheit, 2014; Mattocks et al., 2016; Bourdon et al., 2017; Buckner et al., 2017; Kenneally et al., 2018; Michalsik, 2018; Laursen & Buchheit, 2019; Skarbalius et al., 2019). Targeted coaching of athletes to achieve the best results in the most important matches is based on the principles of coaching management: *supercompensation phenomenon (fatigue), the phenomenon of two factors, adaptation, increased loads and overloads, relationship of training and sport performance or sport performance and training, the principle of adequacy of the structure of energy sources in competition and training sessions, the concept of concentrated, maintaining and recovery training programs, application of retraining programs, monitoring of coaching and sport performance* (Halson, 2014; Bourdon et al., 2017; Buckner et al., 2017; Cardinale & Varley, 2017; Coutts et al., 2017; Gabbett et al., 2017; McGuigan, 2017; Cunanan et al., 2018; Kellmann et al., 2018; Mujika et al., 2018; Bompa & Buzzichelli, 2019; Skarbalius et al., 2019). The coaching programs used must be adequate to the abilities of athletes, depending on their age, gender and mastery. However, there are no specific coaching models, the characteristics of coaching models are undefined. Athletes achieve the best results by training in a variety of ways, using different training models (Laursen & Buchheit, 2019; Mujika et al., 2018). Moreover, some sports researchers (Barrett et al., 2016; Bartlett et al., 2017; Bompa & Buzzichelli, 2019) present different characteristics of training models compared to others (Bourdon et al., 2017; Laursen & Buchheit, 2019; Skarbalius et al., 2019). Different features of the models also lead to different interpretations of the models used (Cardinale, 2000; Halson & Jeukendrup, 2004; Halson, 2014; Gaudino et al., 2015; Bourdon et al.,

2017; Buckner et al., 2017). Depending on the sport, there is not only a large abundance of both independent and dependent variables, but also their differences. Especially many of them appear while coaching team sports (Haugen et al., 2016; Hermassi et al., 2018; Heidari et al., 2019).

Opinions of researchers dealing with elite women's and men's handball coaching (Skarbalius, 2003; Michalsik, 2015; Laursen & Buchheit, 2019; Skarbalius et al., 2019) differ on the coaching models used. This also leads to differences in approaches to management. Although the results of such studies allow for the practical adaptation of the coaching models recommended by the researchers and the application of the criteria for the management of those modelled loads, the biggest problem is that researchers mainly study the individual features of coaching – some of them study microcycles (Clemente et al., 2017), others (Luteberget & Spencer, 2017) – the impact of individual elements of coaching programs on sport performance. There is a problem how to model and manage the coaching of a handball team for one sports season, which would create preconditions for achieving the best sports results of the season.

The problem is not only the coaching criteria to model coaching programs, but also the criteria to manage those coaching models. We have not come across any coaching models which would be effective and suitable for one year and that could be applied for a high-performance handball team.

Therefore, there is a problem in how to manage the modelled coaching of athletes. It is especially relevant what coaching management criteria could be used to manage the applied coaching models for a high-performance female handball team, the one-season competition period duration of which is as long as nine months and the finals of the most important matches take place at different times of the season (at the beginning – in September and November, in the middle – in February, at the end – in May).

Even less research is carried out on the training activities of female handball players. Moreover, the peculiarities of the effect of different factors on high-performance female handball players have not been studied. Peculiarities of the relationship of external and internal loads of high-performance female handball players have not been scientifically grounded.

A study of the literature sources of external and internal loads of high-performance female handball players revealed the phenomenon of the relationship of external and internal loads: external and internal

load indicators and their interaction create preconditions for the development of a coaching program, and at the same time assess the impact of that coaching program. The research problem of the dissertation was to determine the essential external and internal load criteria for team sport performance management (Figure 1), training loads and the athlete's response to the training load, which would allow the development of optimal coaching programs. The study of sources also allowed to systematize the criteria of coaching management (Figure 2).

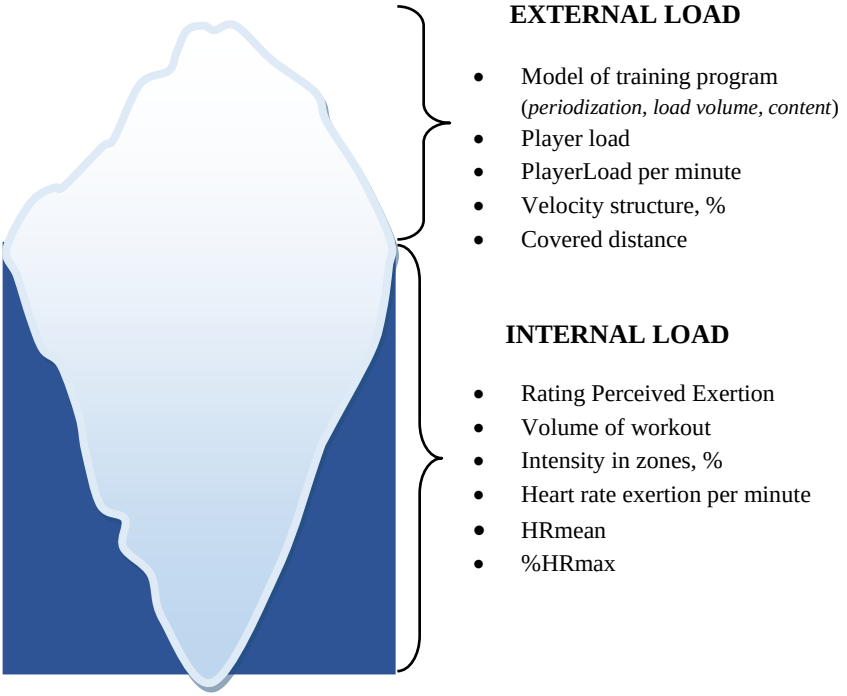


Fig. 1. Features of external and internal loads investigated in the dissertation

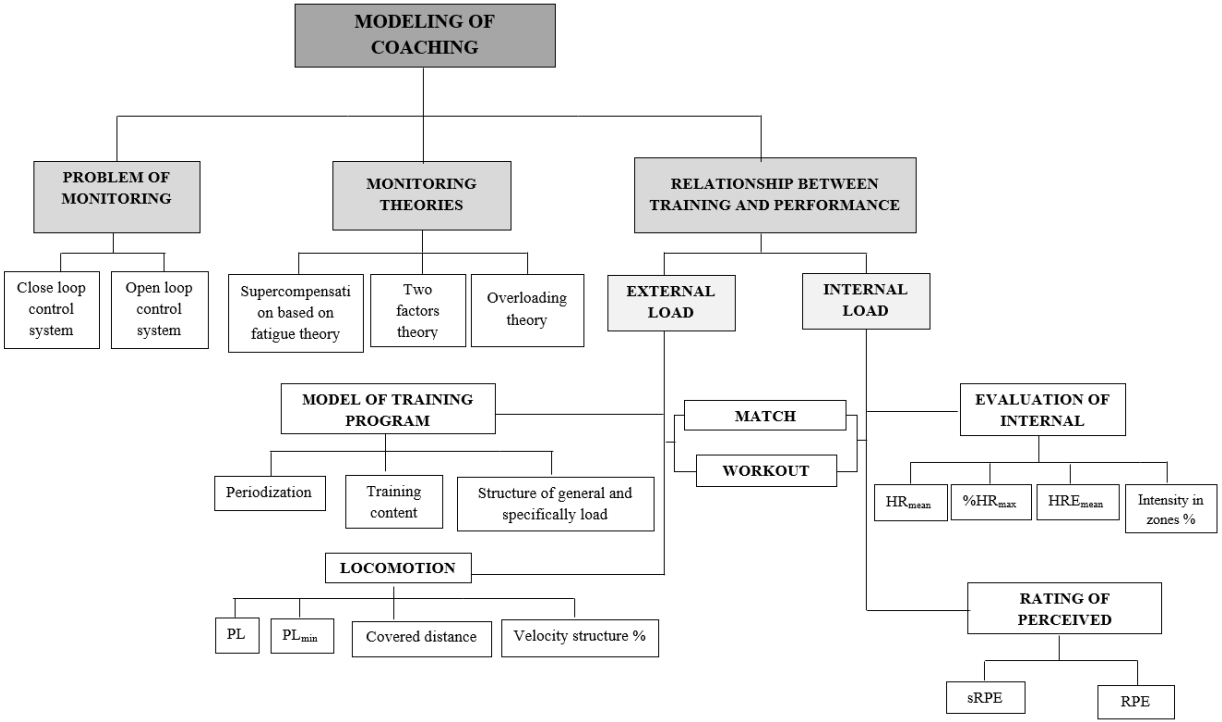


Fig. 2. Hypothetical model of coaching modelling management (compiled by the author)

2. RESEARCH METHODS AND ORGANIZATION

To perform the research, the permission of Kaunas Regional Biomedical Research Ethics Committee No. BE-2-55 was obtained.

2.1. Research methods

Theoretical analysis of the research problem

Theoretical analysis of the research problem allowed to create a hypothetical model of coaching modeling management for high-performance female handball players.

Model experiment

From the end of August 2017 to the end of May 2018, a **model experiment** of coaching for high-performance female handball players was conducted. During the annual cycle of the sports season, women handball players trained for 43 weeks, 216 days. During that time, a total of 229 training sessions were organized for them, of which 179 were workouts and 50 matches. The practice sessions investigated were:

- ***matches*** *– official matches, n = 30;*
- ***control matches*** *– friendly matches, n = 4;*
- ***pre-competition workouts*** *– carried out the day before the match, n = 19;*
- ***integral practice sessions*** *– coaching close to the nature of the match, n = 13;*
- ***technical and tactical practice sessions*** *and tactical practice sessions – technical training and application of strategy for the upcoming matches, n = 32;*
- ***specific endurance training,*** *n = 8;*
- ***strength training,*** *n = 19.*

Recording external and internal load indices

External loads

Registration of training loads. External loads were recorded by Global Positioning System (GPS) devices: OptimeEyeS5 and ClearSkyT6 (Catapult, Australia) (www.catapultsports.com). The devices work in conjunction with heart rate monitors (Polar Team System T31-CODED, Finland) and the computer system Open field.

The indices were recorded with the devices and processed in the computer system (Figure 3).

Fig. 3. Equipment for determining external (accelerations) (CATAPULT) and internal (HR) loads (POLAR)

Two types of GPS devices were used to detect player loads: **OptimeEyeS5** and **ClearSkyT6**. They both register:

1) ***PlayerLoad*** *of practice sessions* ***(PL)*** *in Arbitrary Units(AU),*

2) Calculated ***PlayerLoad per minute – PL_{min} –PL_{min} · m^{-1}***.

Player Load calculated

Player Load is the sum of the accelerations across all axes of the internal tri-axial accelerometer during movement. It takes into account instantaneous rate of change of acceleration and divides it by a scaling factor (divided by 100). The scaling factor is used to reduce the total value of the Accumulated Player Load thereby making it easier to work with during analysis.

Instantaneous Player Load Formula

$$\text{Plyr.Load} = \sqrt{\left(\left(fwd_{i=i+1} - fwd_{i=i}\right)^2 + \left(side_{i=i+1} - side_{i=i}\right)^2 + \left(up_{i=i+1} - up_{i=i}\right)^2\right)}$$

fwd: forward acceleration

side: sideways acceleration

up: upwards acceleration

t: time

Accumulated Player Load Formula

$$\text{Plyr. Ld(acc)}_{t=n} = \sum_{i=0}^{i=n} \sqrt{\left(\left(fwd_{i=i+1} - fwd_{i=i}\right)^2 + \left(side_{i=i+1} - side_{i=i}\right)^2 + \left(up_{i=i+1} - up_{i=i}\right)^2\right)}$$

for $t = 0,0.01,0.02,0.03 \ldots n$

Fig. 4. Player Load formula

Internal loads

Objective methods. Heart rate monitors were used to determine the intensity of the players (Polar). In addition, a heart rate monitor placed on the chest (Polar Team System T31-CODED, Finland) recorded heart rate every second (Figure 5). The software (Catapult) for estimating the acceleration characteristics also allowed to evaluate the load intensity characteristics.

The Catapult system, operating in conjunction with a heart rate monitor, made it possible to record the following load intensity indicators:

- $HR_{max;}$
- $HR_{mean;}$
- $\%HR_{max}$
- *Heart rate exertion per minute* – HRE_{min}

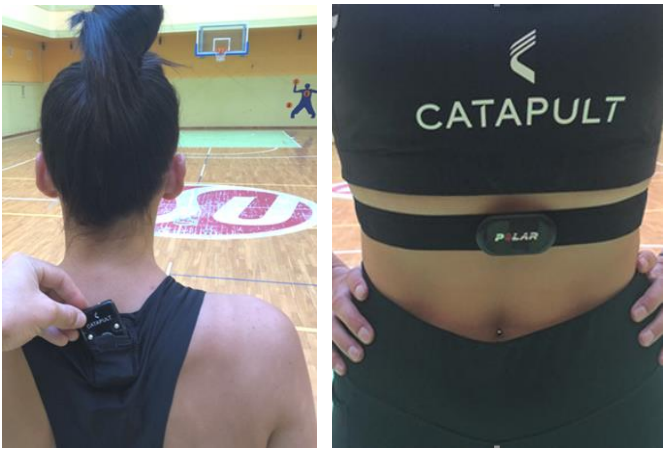


Figure 5. Principle of heart rate monitor operation

HRE_{min} was assessed by cardiac function, it describes the intensity of activity and only the methodology of modern technologies registers this criterion. Athlete workload was also assessed on the basis of intensity zones ($\%HR_{max}$) (Stagno et al., 2007), the duration of training in the relevant area and an estimate of the relevant area (Barnes et al., 2014).

Subjective methods. The Athletes' Rating Perceived Exertion (RPE) methodology was used to assess the training and match efforts of female handball players (Foster et al., 2001). The methodology is based on the evaluation of the athlete's **efforts** and **fatigue** on the Borg scale (from 0 to 10 points) after the practice session (Borg, 1990; Foster et al., 2001) (Figure 6). After each practice session, the athletes rated their efforts and fatigue during the practice session on a ten-point scale. All practice session activities were included in the evaluation of the Rating Perceived Exertion (RPE): *warming up, training, recovery during the practice session* (Foster et al., 2001).

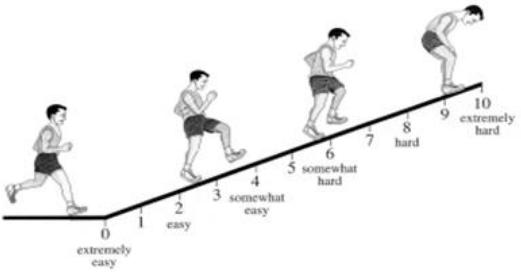


Figure 6. Borg Rating Scale of Perceived Exertion (Borg, 1990)

The **session Rating Perceived Exertion (sRPE)** was estimated by estimating the effort index, also depending on the duration of the practice session. The session Rating Perceived Exertion was determined by the applicable formula (Foster et al., 2001, 2017) – The session Rating Perceived Exertion (sRPE) is multiplied by the duration (D) of the practice session (minutes):

$$\mathbf{sRPE = RPE \times D}$$

Qualitative research

Semi-structured interview

The purpose of the structured interview was to reveal the peculiarities of sports and academic activities. With the help of a semi-structured interview method, from the point of view of education science, the atitudes of elite female handball players towards the goals of sports and academic activities were revealed. *The qualitative study was conducted in June, at the end of the 2017–2018 season. Nine elite women handball players were interviewed.*

Data processing – mathematical statistics

Comparative analysis was performed using statistical methods (arithmetic mean and standard deviation) (the reliability of the differences was determined by the student's *t*-criterion applying a 95 % significance level ($p < 0.05$) in the Excel program (Microsoft Office 365 ProPlus). Pearson correlation coefficients were used to determine the relationship of the indices. Differences were also assessed using the Effect size (ES) Hopkins scale: *trivial < 0.2; small 0.2–0.6; medium 0.6–1.2; large 1.2–2.0; very large > 2.0* (Hopkins, 2002, 2004, 2017).

2.2. Subjects

Research participants were Lithuanian women's handball champions of 2017–2018, Lithuanian Cup and Super Cup winners ACME-Žalgiris handball players (n = 9) (Table 1).

Table 1. Subjects

Players	**Age** (years)	**Height** (cm)	**Body mass** (kg)	**Body fat mass** (%)	**Body fat mass** (kg)	**Fat free mass** (kg)	**VO_{2max}** ($ml \cdot kg^{-1} \cdot min^{-1}$)	**HR_{max}** ($beats \cdot min^{-1}$)	**Representation in the highest league** (year)
Line player									
1	27	174	63.4	16.1	10.4	53.1	58.8	192	10
Left and Right Wing players									
3	23	169	60.3	17.4	10.4	49.9	46.8	200	4
	22	170	62.7	18.3	11.4	51.3	54.1	178	5
	22	175	68.2	18.1	12.5	55.1	45	185	7
Second line players									
5	25	170	65.5	23.3	15.3	50.2	49.4	180	7
	22	178	64.6	20.5	13.4	51.2	44.6	191	5
	22	170	66.3	21.3	14.1	52.2	49.1	201	5
	23	178	79.8	29.0	23.2	56.7	44.4	190	5
	22	169	76.2	21.6	16.6	60.1	48.6	193	5

2.3. Protocol of recording external and internal training loads

Loads of training. Seven different types of loads were recorded: ***official matches, control matches, integral, pre-competition, technical-tactical, specific endurance and strength training.***

External loads were recorded in two ways – by recording the player load indicators and the structure of the training content. Before training, a vest (Catapult) was placed on the back of the subject, in which the GPS device OptimeEyeS5 or ClearSkyT6 was placed on the back. In addition, a heart rate monitor (Polar) was placed on the chest to record internal loads. The devices were switched on before the start of training and switched off after the end of the training session. After training, the devices were connected to a computer system and the data was transferred to a computer program Open Field. In the Open Field program, the data were processed and transferred to the Open Cloud system. From the Open Cloud system, the indices in Excel format were transferred to a computer and statistical analysis was performed (Figure 7).

Internal loads were recorded after the training sessions. After the loads, the players recorded their perceived exertion on a ten-point $Borg_{0–10}$ scale. The players were familiar with this methodology and had many years of experience.

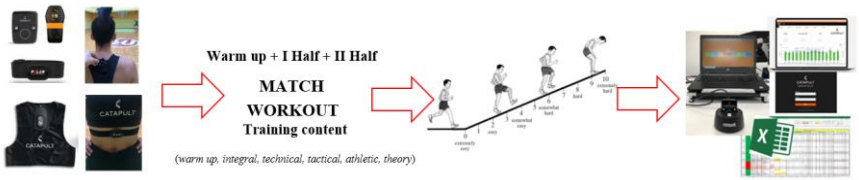


Figure 7. Study protocol of external and internal loads applied to players during practice sessions

3. RESULTS

3.1. Model of season training content

The structure of the training program content

The percentage structure of the content of the one-season training program in high-performance female handball teams was made up of: warming up (27 %), integral (24 %), tactical (21 %), technical and athletic (12 %), theoretical (4 %) training (Figure 8).

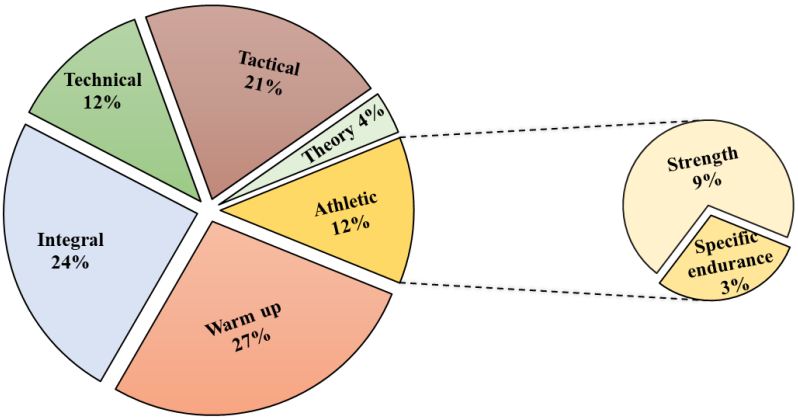


Figure 8. The structure of high-performance female handball players' training content

3.2. Season periodization model

Due the calendar of matches, the one-season (2017–2018) 52-week training of high-performance female handball players embraced a mixed structure of sports season training periodization:

- ***classical*** *structure of the annual periodization,*
- ***block*** *periodization structure (Figure 9).*

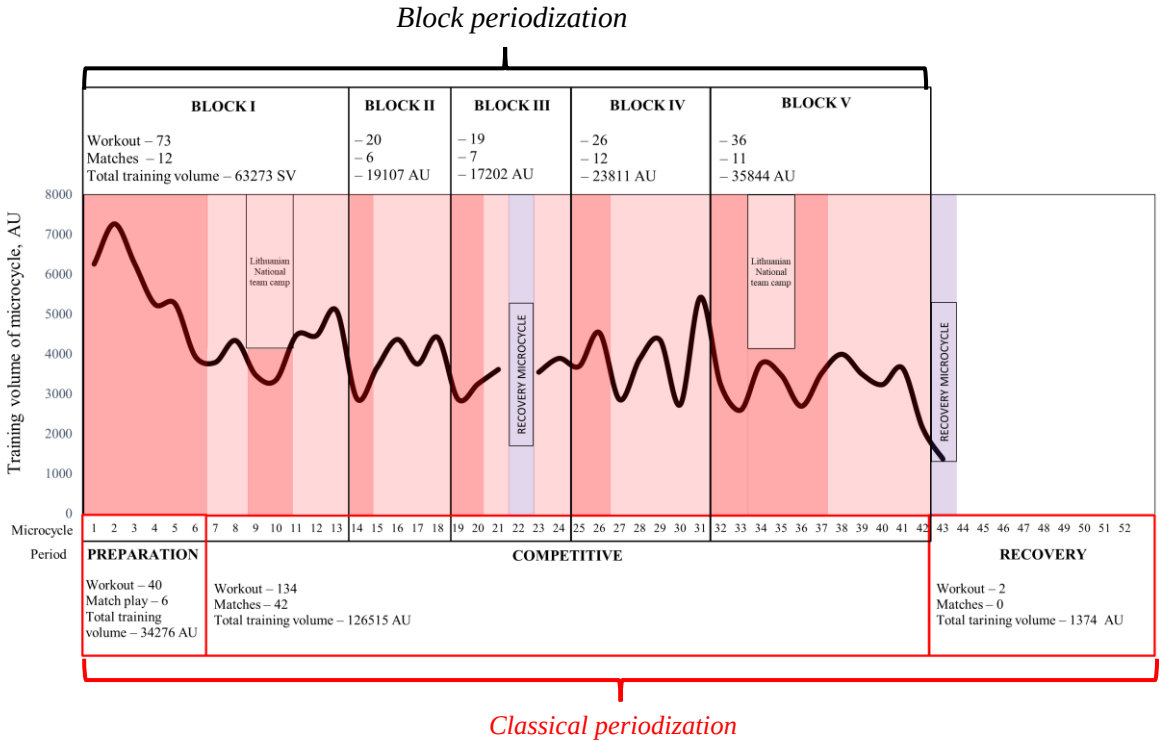


Fig. 9. Seasonal changes training loads

Microcycle load

The maximum microcycle load was determined during the preparatory period, in the basic microcycle – 7270 AU (808 ± 195). *It is noteworthy that during the preparatory period, handball players trained twice a day*. The minimum microcycle load was determined in the recovery microcycle – 1374 AU (687 ± 119) at the end of the competition period.

Basic microcycle load varied from 3355 to 7270 AU. The microcycle load of matches varied from 2145 AU to 5429 AU. Retraining microcycle load varied from 2697 to 4541 AU. Recovery-retraining microcycle load varied from 2601 to 3769 AU. Recovery microcycle load was 1374 AU (Figure 10). *It should be noted that the load of competition microcycles increased, while that of retraining and other microcycles decreased.*

3.3. Training content and loads

Changes in training sessions depend on changes in the sport performance of handball players – the ongoing detraining processes and the need to retrain the individual components of sport performance, as well as on the competition and match calendar. The sequence of training types used in the blocks is shown in Figure 11.

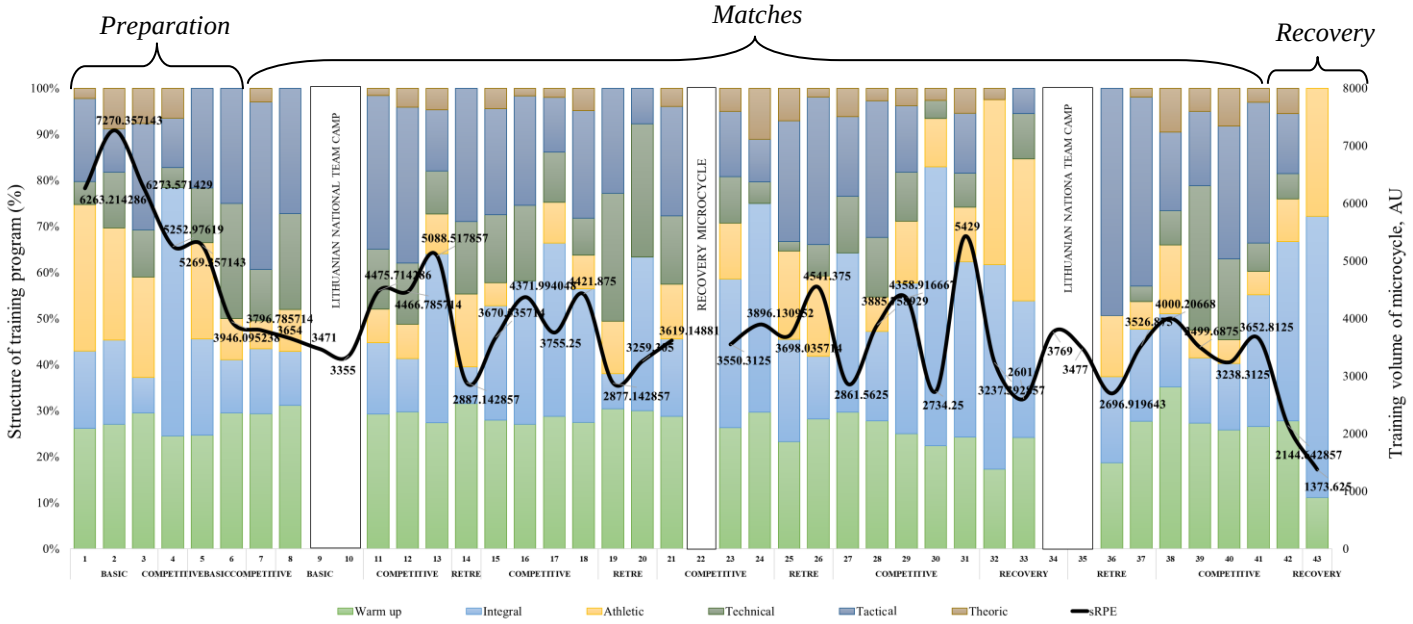
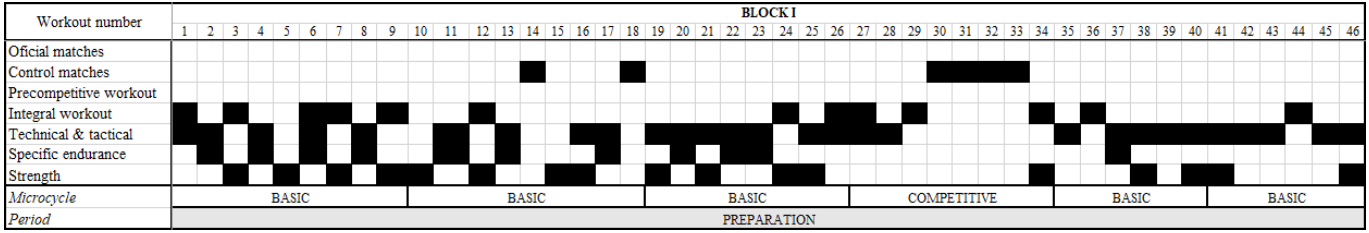
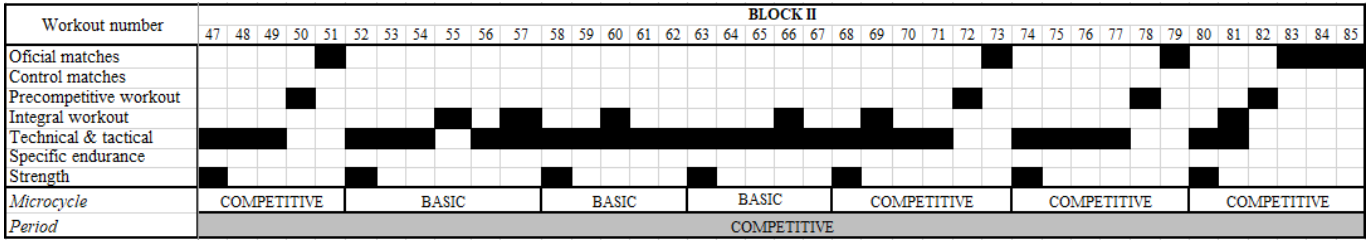
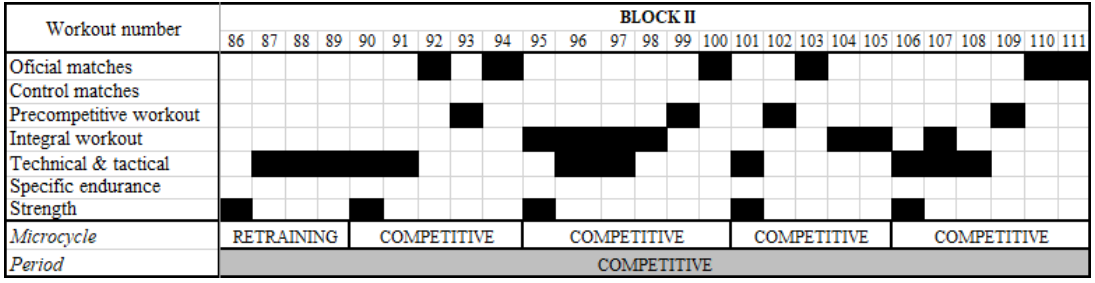


Fig. 10. Content structure and microcycle load model of high-performance female handball players' training program
Note: RETRE – retraining


Workout number
BLOCK I
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46
Oficial matches
Control matches
Precompetitive workout
Integral workout
Technical & tactical
Specific endurance
Strength
Microcycle
BASIC
BASIC
BASIC
COMPETITIVE
BASIC
BASIC
Period
PREPARATION


Workout number
BLOCK II
47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85
Oficial matches
Control matches
Precompetitive workout
Integral workout
Technical & tactical
Specific endurance
Strength
Microcycle
COMPETITIVE
BASIC
BASIC
BASIC
COMPETITIVE
COMPETITIVE
COMPETITIVE
Period
COMPETITIVE


Workout number
BLOCK II
86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111
Oficial matches
Control matches
Precompetitive workout
Integral workout
Technical & tactical
Specific endurance
Strength
Microcycle
RETRAINING
COMPETITIVE
COMPETITIVE
COMPETITIVE
COMPETITIVE
Period
COMPETITIVE

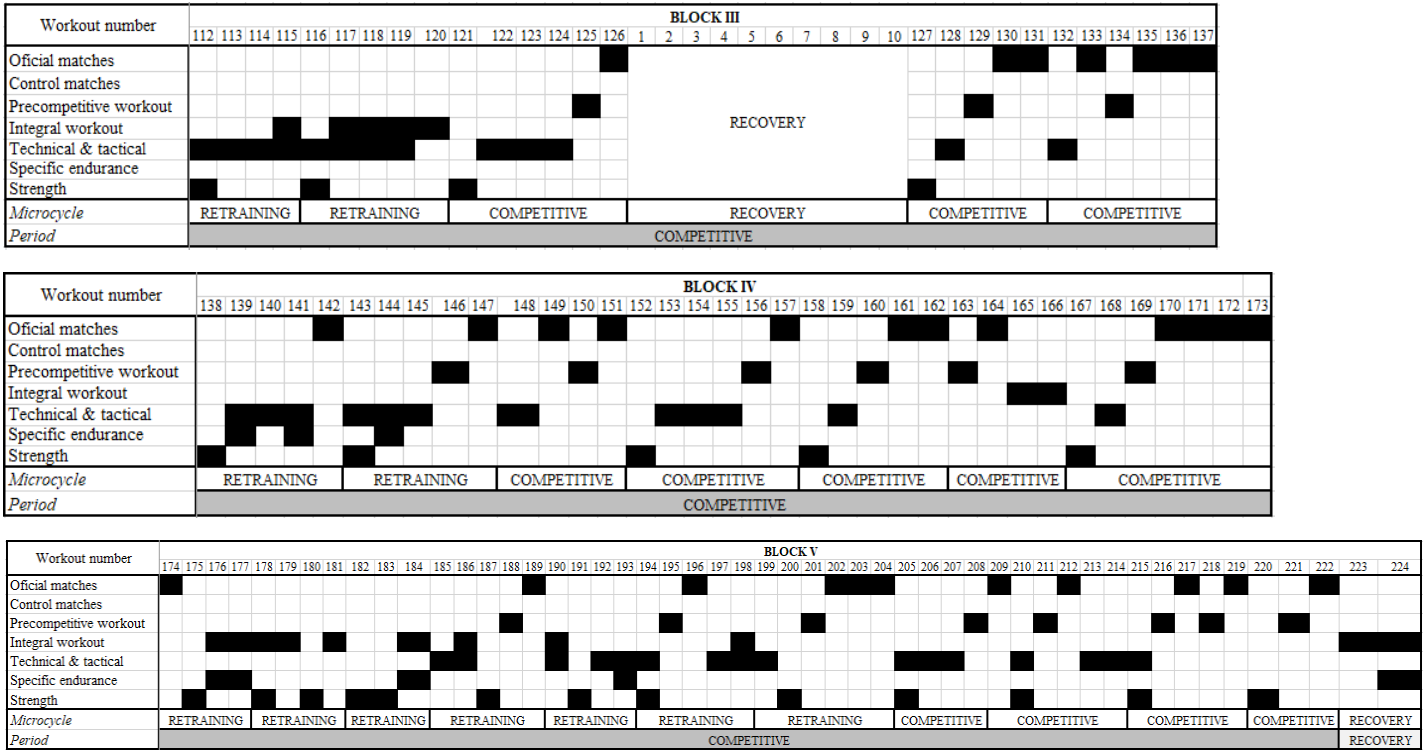


Fig. 11. A model of different training for high-performance female handball players in an annual season

Features of the training program

The relationships of the investigated RPE indices with the external load indices were determined (Table 2). RPE relationships with $\%HR_{max}$, HR_{mean} or PL_{min} criteria were average – r = 0.46 ÷ 0.49.

Table 2. Interrelationships between internal and external load indicators for high-performance female handball players

	EXTERNAL LOAD				INTERNAL LOAD								
	PL	CL 95% [max/min]	**Pl_{min}**	CL 95%	**HR_{mean}**	CL 95%	**$\%HR_{max}$**	CL 95%	**HRE_{min}**	CL 95%	**RPE**	CL 95%	**sRPE**	CL 95%
Oficial matches	**597**	[527-667]	**7.5**	[6.5-8.5]	**157**	[149-165]	**78**	[75-81]	**70**	[63-78]	**7.9**	[7.7-8.2]	**867**	[816-919]
Control matches	**598**	[393-803]	**6.5**	[4.9-8.2]	**152**	[140-163]	**75**	[70-80]	**62**	[47-62]	**8.1**	[7.0-9.2]	**837**	[718-957]
Precompetitive workout	**409**	[364-454]	**4.8**	[6.5-8.5]	**135**	[128-143]	**67**	[64-71]	**44**	[37-50]	**7.1**	[6.8-7.3]	**627**	[602-652]
Integral workout	**489**	[428-550]	**5.9**	[5.2-6.7]	**139**	[128-149]	**69**	[63-73]	**47**	[41-53]	**7.6**	[7.3-7.9]	**684**	[645-723]
Technical & tactical	**442**	[401-483]	**5.1**	[4.6-5.5]	**132**	[122-141]	**65**	[61-70]	**44**	[36-51]	**7.2**	[7.1-7.4]	**662**	[642-682]
Specific endurance	**466**	[367-565]	**6.5**	[5.4-7.6]	**138**	[127-148]	**68**	[64-73]	**47**	[39-54]	**8.5**	[8.2-8.7]	**758**	[719-758]
Strength											**7.6**	[7.2-8.0]	**797**	[704-891]

RELATIONSHIP BETWEEN EXTERNAL AND INTERNAL LOAD

	PL	**Pl_{min}**	**HR_{mean}**	**$\%HR_{max}$**	**HRE_{min}**	**RPE**	**sRPE**
PL	1						
Pl_{min}	0.849	1					
HR_{mean}	**0.947**	0.847	1				
$\%HR_{max}$	**0.940**	0.850	**0.999**	1			
HRE_{min}	**0.946**	0.846	**0.989**	**0.989**	1		
RPE	0.559	0.796	0.491	0.477	0.460	1	
sRPE	**0.936**	**0.937**	**0.920**	**0.913**	**0.926**	0.748	1

Note: * confidence limits (CL)

Assessing the PL_{min} indices of high-performance female handball players with functional capacity (**%**VO_{2max} criterion), it was found that handball players with higher capacity showed higher PL_{min} (Figure 12).

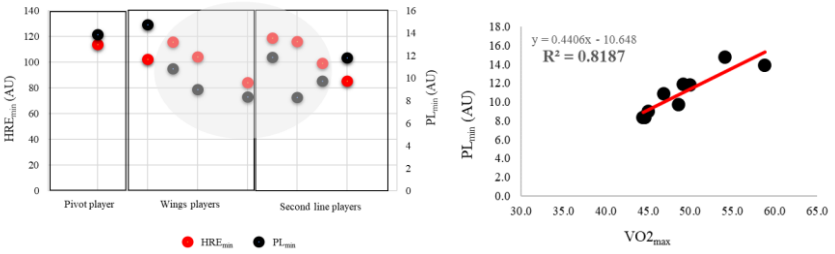


Fig. 12. Relationship of external (PL_{min}) and internal (**%**VO_{2max}) load indicators of matches in high-performance female handball players

4. PECULIARITIES OF HIGH-PERFORMANCE FEMALE HANDBALL PLAYERS' ANNUAL CYCLE COACHING

The **model experiment** aimed to develop a one-season coaching model for high-performance female handball players. The problem was how to manage the sport performance of female handball players to achieve the best sports results several times during the nine-month competition period. *Coaching a handball team is a multifaceted process (Manchado et al., 2018), however, it is argued that only a planned and managed process of coaching athletes creates favourable conditions for them to achieve the best sports results during the most important competitions, and also that different team-coaching models may create different or even similar sport performance models (Laursen & Buchheit, 2019*).

Hypothetical coaching and management model. A study of literature on a systematic approach to coaching handball players (Souza et al., 2006; Thorlund et al., 2008; Skarbalius, 2010; Vila et al., 2012, 2020; Manchado et al., 2013a, 2018; Michalsik, 2015, 2017, 2018; Luteberget & Spencer, 2017; Luteberget et al., 2018; Valeria et al., 2017; Wik et al., 2017; Wagner & Fuchs, 2018; Wagner et al., 2019, 2020; Skarbalius et al., 2019) did not disclose the criteria for systematic management of one sports season coaching, also the coaching modeling management criteria. A meta-analysis of coaching management of athletes (in general) and handball players (specifically) allowed the development of a hypothetical model for the management modeling of coaching high-performance female handball players (Figure 2), *in which the independent variables were training periodization, training loads and content, external loads of matches and training sessions, and dependent variables – indices of internal loads of handball matches and training sessions, and sports performance described by sports results.*

Annual periodization model. *The study revealed the phenomenon of integration of classical and block periodization of high-performance female handball players' coaching in one sports season, based on the application of the principles of integral (Muijka et al., 2018) classical (Matveyev, 1964) and block (Issurin, 2008) periodization.* We developed and effectively applied the coaching model of an annual periodization cycle of one sports season for high-performance handball players, determined by the competition calendar,

when the highest level of sport performance had to be achieved five times during the season. *It has been established that the structural unit for the preparation of the periodization of the sports season for high-performance female handball players is the training block, based on periodic recurring blocks depending on the peculiarities of changes in the competition calendar and the sport performance of female handball players, and including the features of accumulation (preparatory period modeling), transmutation (pre-competition mesocycle modeling) and realization (competition period modeling). Such a modified coaching program for high-performance female handball players allowed the team to win the gold medals in the Lithuanian Championship 2017–2018, as well as to win other titles in Lithuania and thus develop their comprehensively educated and mature personalities. However, regardless of how the classical or block periodization classification is theoretically followed, the smallest element of the sports season coaching structure – the microcycle – is the essential element of female handball players' coaching program that allows managing changes in handball players' detraining.*

The model of training loads, content and their changes. Athlete coaching begins with the concept and planning of training (Busso & Thomas, 2006; Mujika & Busso, 2008; Thorpe et al., 2016; Coutts et al., 2017; McGuigan, 2017; Manchado et al., 2018; Michalsik, 2018; Bompa & Buzzichelli, 2019; Impellizzeri et al., 2019; Mujika et al., 2018; Skarbalius et al., 2019). Management includes prediction of results, modeling of competition performance indices, creation and execution of a competition program, and adjustment of sports training (Lambert & Mujika, 2013; Buchheit, 2014; Mattocks et al., 2016; Bourdon et al., 2017; Buckner et al., 2017; Kenneally et al., 2018; Michalsik, 2018; Laursen & Buchheit, 2019; Skarbalius et al., 2019). *Percentage structure of the content elements of the coaching program, changes in the content of practice sessions are also the criteria for modeling the coaching program for high-performance female handball players.*

Therefore, this study developed and effectively applied a one-year individual block training program for high-performance female handball players, consisting of a percentage structure of warming up, integral, tactical, technical, athletic, and theoretical training, and it can be accepted as a one-year coaching model for high-performance handball players (Figure 8).

A model of training loads applied to high-performance female

handball players was developed. It varied depending on the competition calendar. The values of loads of microcycles, block training sessions and matches were revealed.

Changes in training content were revealed (Figure 11) using the concept of concentrated coaching of athletes (Rosenblatt, 2014), which allowed for the retraining of female handball players' sport performance at an appropriate time.

It was found that the effectiveness of the one-year coaching model for high-performance female handball players was determined by specific training (integrated training – 24 %), and the uniqueness was the fact that the time devoted to warming up (27 %) and the indicators of strength and specific endurance training were indicated (Figure 8). Consequently, the specific sport performance of high-performance female handball players is the most significant precondition for winning a handball match.

External and internal training loads. Coaching management is conditioned by one of the principles of coaching – training and sport performance relationship (Lambert & Borresen, 2006; Coutts et al., 2017; Mujika et al., 2018). The dissertation research emphasizes the relationship of training and sport performance as based on one of the elements of a closed loop control system – feedback (Adams, 1971). In the coaching management chain for high-performance female handball players, external factors *(structure of training parts, structure of periodization, PL, PL_{min}, distance covered, percentage structure of movement speed*) were used as an independent variable of the input, and handball players' responses to loads were dependent variables and were measured by internal load criteria (*sRPE, RPE, HR_{mean}, $\%HR_{max}$, PL_{min}, intensity percentage structure)*. Based on the application of the principles of stress-adaptation or fatigue supercompensation (Bompa & Buzzichelli, 2019) and two factors (Banister et al., 1975; Busso & Thomas, 2006; Zatsiorsky & Kraemer, 2006) in athlete coaching, the responses of handball players to the external loads of the applied training was revealed and evaluated by the internal loads (Foster, 1998; Foster et al., 1996, 2001, 2017). *For the first time, the values of external and internal load indices of matches and other practice sessions were determined, which would make it possible to manage high-performance handball players' coaching not only by developing coaching programs, but also by modeling the rest periods between practice sessions. The values of external and internal loads of applied training (match, control matches, integral training, technical-tactical, pre-competition, strength,*

endurance) can be used as criteria for modeling and management of handball players' coaching.

For practical purposes we suggest that the training effect on high-performance female handball players could be determined using one of the three criteria – % HR_{max}, HR_{mean} or PL_{min} (Table 2).

The %HR_{max} and sRPE criteria were found to be informative in assessing the response of high-performance handball players to the applied physical loads.

It is recommended to apply the model of acceleration skill development (Lutebergert et al., 2018; Laursen & Buchheit, 2019) taking into account changes in leg muscle power (speed force indices), detraining and the need for retraining of the appropriate acceleration skill determined by the match schedule (Skarbalius, 2010; Rosenblatt, 2014; Mujika el al., 2018).

Objective and subjective coaching management criteria. One of the tasks of the dissertation research was to determine the management criteria for coaching modeling (Impellizzeri et al., 2019). The study used the up-to-date CATAPULT equipment (Australia), which allowed both valid and reliable determination of external load indices (Luteberget & Spencer, 2017). At the same time, the responses of handball players to external loads were measured in both objective and subjective ways (Foster, 1998; Foster et al., 2017). The study revealed the criteria for assessing the external loads of handball players (PL and PL_{min}) as informative features of training, and internal load assessment criteria (%HR_{max} and sRPE) as informative sport performance criteria. The different sport performance of subjects was determined by evaluating the PL_{min} indicator together with the HRE_{min} indicator. Handball players with a higher player load (PL_{min}) but a lower load rate demonstrate better sport performance, and vice versa (Figure 12). However, it must be emphasized that when assessing handball players with different sport performance (Wagner et al., 2020), we have to have in mind that internal and external load factors affect each other differently (Luteberget & Spencer, 2017). Assessing the dependence of player load on the functional fitness evaluated by the VO_{2max} criterion, we see that players with better functional fitness (measured by the VO_{2max} criterion) will have higher player load per minute with as much as 82 percent probability. *Consequently, the indices of external and internal loads are also criteria for modeling and managing the coaching of handball players.*

Following the principle of relationship between athletes' training

and sport performance, they evaluated the internal loads of each workout throughout the season and thus the relationship of external loads with internal loads was assessed. At the same time, such a subjective assessment of internal loads (RPE) was a criterion for monitoring the coaching process of a closed loop control system and should be recommended for the assessment of internal loads.

CONCLUSIONS

1. The developed mixed periodization model of high-performance female handball players' sports season coaching allows to effectively manage changes in players' detraining and retraining so that sport performance is maintained for nine months and the best results are achieved several times per season.

2. Model characteristics of external and internal load indices of high-performance female handball players' in different positions matches, control matches, pre-competition, integral training, technical-tactical, strength, and endurance training are described.

3. Criteria for the management of handball players' coaching were established:

- *mixed periodization block models,*
- *values of external and internal load indies of matches, control matches, pre-competition, integral training, technical-tactical, strength, and endurance training.*

4. An effective model of high-performance female handball players; coaching promotes the education of young people seeking for a dual social career.

PRACTICAL RECOMMENDATIONS

1. Based on the principles of classical periodization, it is recommended to model the season coaching program in blocks.

2. The developed high-performance female handball players' coaching model for the sports season can be used not only by teams of players of the same mastership levels, but based on the principles of the model structure, coaches will be able to develop their coaching training programs for teams of different mastership levels or ages.

3. The target model characteristics of microcycles, block contents and load volume were developed.

4. Coaches will be able to follow the presented sequence of the seven loads studied (matches, control matches, integral training, pre-competition, technical-tactical, strength, and endurance) throughout the season, managing the players' detraining and retraining processes.

5. The defined characteristics of external and internal loads of players of different positions will allow individualization of training loads for players.

SANTRAUKA

Sportininkų treniravimas yra daugiaplanis vyksmas (Lambert & Mujika, 2013; Buchheit, 2014; Mattocks et al., 2016; Bourdon et al., 2017; Buckner et al., 2017; Conte, Kolb, Scanlan, & Santolamazza, 2018; Kenneally, Casado, & Santos-Concejero, 2018; Michalsik, 2018; Bompa & Buzzichelli, 2019; Laursen & Buchheit, 2019; Skarbalius, Vidūnaitė, Kniubaitė, Rėklaitienė, & Simanavičius, 2019), reikalaujantis laikytis bendrųjų sistemos valdymo (Adams, 1971; Schmidt, 1975), treniravimo modeliavimo bei valdymo (Banister, Calvert, Savage, & Bach, 1975; Banister, 1991; Halson, 2014; Bourdon et al., 2017; Buchner et al., 2017; Cardinale & Varley, 2017; Coutts et al., 2017; Cunanan et al., 2017; Kellmann, Bertollo, Bosquet, Brink, Coutts, Duffield, & Kallus, 2017; McGuigan, 2017) principų.

Sporto mokslininkai teigia, kad tik planingas, tinkamai valdomas sportininkų rengimo vyksmas sudaro sportininkams palankias sąlygas geriausius rezultatus pasiekti per svarbiausias varžybas (Busso & Thomas, 2006; Mujika & Busso, 2008; Thorpe et al., 2016; Coutts et al., 2017; McGuigan, 2017; Manchado et al., 2018; Michalsik, 2018; Bompa & Buzzichelli, 2019; Impellizzeri et al., 2019; Mujika et al., 2018; Skarbalius et al., 2019). Valdymas apima rezultatų prognozavimą, varžybinės veiklos modeliavimą, varžybų programos sudarymą ir vykdymą, sportinio rengimo koregavimą (Lambert & Mujika, 2013; Buchheit, 2014; Mattocks et al., 2016; Bourdon et al., 2017; Buckner et al., 2017; Kenneally et al., 2018; Michalsik, 2018; Laursen & Buchheit, 2019; Skarbalius et al., 2019). Kryptingas sportininkų treniravimas, kad per svarbiausias varžybas jie pasiektų geriausius rezultatus, remiasi treniravimo valdymo principais: *superkompensacija (nuovargio), dviejų veiksnių, prisitaikymo ir padidintų krūvių bei perkrūvių, fenomenu, rengimo ir parengtumo arba parengtumo ir rengimo sąveika, energijos šaltinių rungtyniaujant* ir *treniruojantis atitikimo principu, koncentruotų, palaikomųjų ir atgaunamųjų rengimo programų koncepcija, atsigavimo programų taikymu, treniravimo ir parengtumo stebėsena* (Halson, 2014; Bourdon et al., 2017; Buckner et al., 2017; Cardinale & Varley, 2017; Coutts et al., 2017; Gabbett et al., 2017; McGuigan, 2017; Cunanan et al., 2018; Kellmann et al., 2018; Mujika et al., 2018; Bompa & Buzzichelli, 2019; Skarbalius et al., 2019). Taikomos treniravimo programos turi atitikti sportininkų pajėgumą, priklausomai nuo jų amžiaus, lyties ir meistriškumo. Tačiau nėra konkrečių treniravimo

modelių, neapibrėžtos treniravimo modelių charakteristikos.

Problema tampa ne tik tai, pagal kokius treniravimo kriterijus modeliuoti treniravimo programas, bet ir kokiais kriterijais remiantis treniravimo modelius valdyti. Neteko aptikti informacijos, kokie treniravimo modeliai yra veiksmingi ir kokius vienerių metų treniravimo modelius reikėtų taikyti didelio meistriškumo rankinio komandos sportininkėms.

Tyrimo problema – kaip modeliuoti didelio meistriškumo rankininkių treniravimą, kad parengtumas būtų išlaikomas devynis varžybų laikotarpio mėnesius?

Tyrimo hipotezė – integrali periodizacija, grįsta klasikinės ir blokų periodizacijos principais, taikomų specifinių ir nespecifinių pratybų krūvių išoriniai ir vidiniai rodikliai leidžia veiksmingai modeliuoti ir valdyti didelio meistriškumo rankininkių treniravimą sezono metu.

Tyrimo objektas – didelio meistriškumo rankininkių treniravimo valdymas ir modeliavimas.

Tyrimo tikslas – parengti didelio meistriškumo rankininkių metinio ciklo treniravimo modelį ir nustatyti jo valdymo kriterijus.

Uždaviniai:

1. Parengti didelio meistriškumo rankininkių sezono treniravimo periodizacijos modelį.
2. Apibūdinti didelio meistriškumo rankininkių rungtynių bei įvairaus turinio pratybų išorinius ir vidinius krūvio rodiklius.
3. Nustatyti treniravimo modeliavimo valdymo kriterijus.
4. Atskleisti didelio meistriškumo rankininkių sportinės ir akademinės veiklos ypatumus.

Disertacijos mokslinis naujumas. Remiantis klasikinės ir blokų periodizacijos principais, parengtas didelio meistriškumo rankininkių sportinio sezono treniravimo modelis, nustatytos optimalios blokų trukmės, treniravimo krūvių ir turinio rodiklių reikšmės, skirtingų pratybų krūvių seka, siekiant sulėtinti detreniruotumo procesą arba retreniruoti pablogėjusį parengtumą. Pateiktos įvairių pozicijų didelio meistriškumo rankininkių skirtingo pobūdžio pratybų išorinių (judėjimo) ir vidinių (intensyvumo) krūvio rodiklių modelinės reikšmės. Nustatytos rungtynių ir kontrolinių rungtynių pramankštos, pirmo ir antro kėlinio išorinių ir vidinių krūvio rodiklių reikšmės. Nustatyti didelio meistriškumo rankinio komandos sezono valdymo kriterijai (periodizacijos elementai, treniravimo krūviai ir turinys, pratybų pobūdis, išoriniai ir vidiniai krūvio rodikliai).

IŠVADOS

1. Parengtas didelio meistriškumo rankininkių mišrios periodizacijos treniravimo modelis leidžia veiksmingai valdyti (kaitalioti) žaidėjų detreniruotumą ir retreniruotumą, kad parengtumas būtų išlaikomas devynis mėnesius ir geriausi rezultatai būtų pasiekiami kelis kartus per sezoną.

2. Apibūdintos skirtingų pozicijų didelio meistriškumo rankininkių modelinės rungtynių, kontrolinių rungtynių, priešvaržybinių, integraliojo rengimo, technikos ir taktikos, jėgos, ištvermės pratybų išorinių bei vidinių krūvio rodiklių charakteristikos.

3. Nustatyti rankininkių treniravimo valdymo kriterijai:

● *mišrios periodizacijos blokų modeliai,*

● *rungtynių, kontrolinių rungtynių, priešvaržybinių, integraliojo rengimo, technikos ir taktikos, jėgos, ištvermės pratybų išorinių bei vidinių krūvio rodiklių reikšmės.*

4. Veiksmingai taikomas didelio meistriškumo rankininkių treniravimo modelis skatina jaunuomenę siekti dvejopos karjeros.

APPROVAL OF THE DISSERTATION

Journal articles

1. Kniubaite, A., Skarbalius, A., Clemente, F. M., & Conte, D. (2019). Quantification of external and internal match loads in elite female team handball. *Biology of Sport*, *36*(4), 311.
2. Skarbalius, A., Vidūnaitė, G., Kniubaitė, A., Rėklaitienė, D., & Simanavičius, A. (2019). Importance of sport performance monitoring for sports organization. *Transformations in Business & Economics*, *18*(2).

Other publications

1. Kniubaitė, Audinga; Skarbalius, Antanas. Locomotion and physiological characteristics in semiprofessional female wing handball player // Current issues and new ideas in sport science: abstracts of the 9th conference of the Baltic Sport Science Society, Kaunas, 27–29 April 2016. Kaunas: Lietuvos sporto universitetas, 2016. ISBN 9786098040968. p. 144–145.
2. Kniubaitė, Audinga; Skarbalius, Antanas. Locomotion characteristics in semi-professional female team handball players // Multiplicity of sports science in practice: abstracts of the 10th conference of the Baltic Sport Science Society, Riga, Latvia, 26–28 April 2017. Riga: Latvian Academy of Sport Education, 2017. ISBN9789934520334. p. 27–28.
3. Kniubaitė, A., Skarbalius, A., Conte, D. Quantification of external and internal match loads in elite female team handball // Sport science for sports practice, teacher training and health promotion: 12th conference of Baltic Society of Sport Sciences: April 25–26, 2019, Vilnius, Lithuania: abstracts. Kaunas Vytautas Magnus University, 2019. ISBN 9786094673849. p. 24.
4. Kniubaitė, Audinga; Skarbalius, Antanas. Didelio meistriškumo rankininkių vidinės ir išorinės krūvio charakteristikos rungtyniaujant // Sportininkų rengimo valdymas ir sportininkų darbingumą lemiantys veiksniai: sporto forumas – tarptautinė mokslinė konferencija, skirta Lietuvos sporto universiteto 85-mečiui paminėti: programa ir pranešimų tezės, 2019 lapkr. 21–22 d., Kaunas, Lietuva. Kaunas: Lietuvos sporto universitetas, eISSN 2538-7952. 2019, p. 47.

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Education

2008–2012	Bachelor qualification degree in sport, Professional qualification of coach. Lithuanian Academy of Physical Education
2012–2014	Master of Biology qualifying degree, Sports Physiology and Genetics. Lithuanian Sports University
2015–2019	Doctoral studies in Social Sciences, Education at Lithuanian Sports University

Working experience

2015–2017	Lithuanian Handball Federation
2018 – present	Lecturer at Lithuanian Sports University