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SUBJECTIVE AND OBJECTIVE MARKERS OF WEARINESS IN FEMALE CURLING ATHLETES DURING VARIOUS PERIODS OF THE ANNUAL TRAINING CYCLE

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Subjective and objective markers of weariness in female curling athletes during various periods of the annual training cycle

Abstract. Effective monitoring of the functional state of the athletes of the national team is a critical factor in preventing overtraining and optimizing the training process. The aim of the study is to determine which type of markers (subjective sensations or objective physiological indicators) reacts earlier to the development of weariness in curling athletes, depending on the training period (general preparatory, special preparatory, pre-competition). The retrospective analysis used data from 8 athletes of the Russian national curling team, collected in five time periods (July 2025 – February 2026). The subjective state was assessed on a 10-point scale (analogous to the Borg scale), the objective state was assessed by resting heart rate. The most pronounced lack of correlation between subjective and objective indicators was revealed in the special preparatory period (autumn 2025), where a decrease in subjective scores to 3 points was not accompanied by critical changes in heart rate. In the general preparatory period, the indicators were the most stable, in the pre-competition period, there was a moderate variability in subjective assessments. Subjective markers of weariness are earlier and more sensitive indicators regardless of the training period, which justifies their priority use in the system of monitoring the training process for curling players.

Key words: weariness monitoring, curling, complex coordination sports, weariness markers, highly qualified athletes.

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Субъективные и объективные маркеры утомления у спортсменок в кёрлинге в различные периоды годичного цикла подготовки

Аннотация. Эффективный мониторинг функционального состояния спортсменов сборной команды является критическим фактором профилактики перетренированности и оптимизации тренировочного процесса. Цель исследования – определить, какой тип маркеров (субъективные ощущения или объективные физиологические показатели) раньше реагирует на развитие утомления у спортсменов в кёрлинге в зависимости от периода подготовки (общеподготовительный, специально-подготовительный, предсоревновательный). В ретроспективном анализе использованы данные 8 спортсменок сборной команды России по кёрлингу, собранные в пяти временных периодах (июль 2025 – февраль 2026). Субъективное состояние оценивалось по 10-балльной шкале (аналог шкалы Борга), объективное – по ЧСС покоя. Наиболее выраженное отсутствие корреляции между субъективными и объективными показателями выявлена в специально-подготовительном периоде (осень 2025), где снижение субъективных оценок до 3 баллов не сопровождалось критическими изменениями ЧСС. В общеподготовительный период показатели были наиболее стабильными, в предсоревновательный период наблюдалась умеренная вариабельность субъективных оценок. Субъективные маркеры утомления являются более ранними и чувствительными индикаторами независимо от периода подготовки, что обосновывает их приоритетное использование в системе контроля тренировочного процесса у игроков в кёрлинг.

Ключевые слова: мониторинг утомления, кёрлинг, сложно-координационные виды спорта, маркеры утомления, высококвалифицированные спортсмены.

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Жылдық жаттығу циклінің әртүрлі кезеңдеріндегі әйел керлингшілердегі шаршаудың субъективті және объективті белгілері

Аңдатпа. Ұлттық құрама спортшыларының функционалдық жағдайын тиімді бақылау шамадан тыс жаттығудың алдын алу және жаттығу процесін оңтайландыруда маңызды фактор болып табылады. Зерттеудің мақсаты жаттығу кезеңіне (жалпы дайындық, мамандандырылған дайындық, жарыс алдындағы) байланысты керлинг спортшыларында шаршаудың дамуына қандай маркерлердің (субъективті сезімдер немесе объективті

физиологиялық көрсеткіштер) ертерек жауап беретінін анықтау болды. Ретроспективті талдауда бес уақыт кезеңінде (2025 жылдың шілдесі – 2026 жылдың ақпаны) жиналған Ресейдің керлинг құрамасының сегіз спортшысының деректері пайдаланылды. Субъективті жағдай 10 балдық шкала бойынша (Борг шкаласына ұқсас) бағаланды, ал объективті жағдай тыныштықтағы жүрек соғу жиілігіне негізделіп бағаланды. Субъективті және объективті көрсеткіштер арасындағы корреляцияның ең айқын болмауы мамандандырылған дайындық кезеңінде (2025 жылдың күзі) байқалды, мұнда субъективті бағалаулардың 3 баллға дейін төмендеуі жүрек соғу жиілігінің маңызды өзгерістерімен қатар жүрмеді. Жалпы дайындық кезеңінде көрсеткіштер ең тұрақты болды, ал жарыс алдындағы кезеңде субъективті бағалаулардың орташа өзгергіштігі байқалды. Субъективті шаршау маркерлері дайындық кезеңіне қарамастан ертерек және сезімтал индикаторлар болып табылады, бұл керлинг ойыншыларының жаттығу процесін бақылауда оларды басымдықпен пайдалануды ақтайды.

Түйін сөздер: шаршауды бақылау, керлинг, күрделі үйлестіру спорт түрлері, шаршау белгілері, жоғары білікті спортшылар.

Introduction. In modern high-performance sports, timely detection of signs of fatigue and prevention of overtraining are key tasks of the training process [1]. This is particularly relevant in complex coordination sports such as curling, where precision of movement and psycho-emotional stability play a crucial role in achieving competitive results [2]. In curling, unlike cyclical sports, success is determined not so much by maximum physical capabilities as by the ability to maintain the coordination structure of movements in conditions of increasing fatigue.

Traditionally, objective (heart rate, heart rate variability, biochemical markers) and subjective (self-assessment, Borg scale) methods of monitoring the functional state of athletes are distinguished. According to a systematic review by Saw and co-authors (2016), subjective measures demonstrate greater sensitivity to changes in training load compared to objective indicators [3]. In 85% of the analyzed studies, which revealed differences between the methods, subjective indicators showed greater responsiveness to load changes. Similar data were obtained by Nuuttila and co-authors (2024), who showed that subjective markers signal the development of fatigue earlier, while changes in nighttime heart rate become significant only at later stages [4].

The validity of the Borg scale for assessing muscle fatigue is confirmed by correlations with surface electromyography data. In the work of Morishita and co-authors (2022), it was shown that an increase in perceived tension on the Borg scale correlates with objective signs of muscle fatigue – compression of the EMG signal power spectrum [5]. This confirms that subjective sensations are influenced by a variety of external signals and this can serve as an effective indicator of fatigue even in the absence of expensive equipment for objective diagnosis.

Studies of heart rate variability (HRV) also show that autonomic regulation may change with the development of functional fatigue. According to a review by Flatt and co-authors (2024), a decrease in HRV may be a sign of overtraining, but this indicator has different information content for different sports and is not always sensitive to the current condition of the athlete [6]. In a meta-analysis by Manresa-Rocamora et al. (2021), it was shown that standard resting HRV indicators do not reveal parasympathetic hyperactivity in functionally overtrained athletes, while weekly average HRV values demonstrate a moderate statistical effect [7].

Data on the effect of fatigue on coordination abilities are of particular importance for curling. In a study by Pereira and co-authors (2025) on fatigue in female handball players, it was shown that the development of fatigue leads to significant changes in the coordination abilities of female athletes [8]. At the same time, the variability of movements decreases, which indicates the «freezing» of degrees of freedom, a compensatory strategy aimed at simplifying the motor task. In curling, where the accuracy of a throw depends on the stability of the body and the consistency of movements of the upper and lower limbs, such changes can critically affect performance.

A systematic review by Vasquez-Mercado and co–authors (2024) showed a strong correlation between the subjective assessment of perceived effort and objective methods of monitoring the intensity of the load - maximum repetition and average speed of execution [9]. This confirms the possibility of using subjective scales not only to diagnose fatigue, but also to manage the training process.

In the context of curling, where the training process has a clear periodization (general preparatory, special preparatory and competitive periods), it is especially important to understand how the ratio of subjective and objective markers changes at different stages of training. During the general training period, loads aimed at developing general endurance, strength and coordination prevail. In the special preparatory period, the emphasis shifts to ice training and the development of technical and tactical elements, which places increased demands on the neuromuscular apparatus. The competitive

period is characterized by high psycho-emotional tension and frequent travel.

The problem of the study lies in the lack of scientifically sound data in curling, revealing which type of markers reacts earlier to fatigue in athletes in different periods of the annual cycle.

The purpose of the study is to determine which is an earlier indicator of fatigue – a subjective assessment or objective indicators (resting heart rate).

Research objectives:

1. To conduct a retrospective analysis of the daily indicators of subjective assessment of the condition and resting heart rate of female curlers in the period from July 2025 to February 2026.

2. Identify episodes of critical decline in subjective scores (less than 5 points) and compare them with the dynamics of heart rate.

3. Compare the nature of the ratio of subjective and objective markers in different periods of the annual cycle: general preparatory, special preparatory and pre-competitive.

4. To evaluate the applicability of a simplified analogue of the Borg scale for early detection of fatigue in the curling training process.

5. Formulate practical recommendations for the coaching staff on the use of subjective markers in the control system.

Materials and methods. A retrospective analysis of the monitoring data of the athletes of the Russian national curling team, gathered during training camps and competition periods from July 2025 to February 2026, was carried out. The study involved from 8 female athletes (women, average age 22 ± 2 years, qualified as masters of sports), who are players of the national curling team.

The analysis covered five time periods corresponding to different stages of the one-year training cycle:

Table 1 – The studied stages of preparation

Stage of preparation	Dates	Duration	Nature of workloads
General preparatory	16.07-30.07.2025	15 days	General physical training
Special preparatory	25.08-01.09.2025	8 days	Special physical training on ice, working out technical and tactical elements
Special preparatory	19.08-25.08.2025	7 days	Special physical training on ice, control training, adaptation to different ice conditions
Special preparatory	23.09-30.09.2025	8 days	Ice training, sparring, simulation of competitive situations
Pre-competition	16.10-26.10.2025	11 days	Intensive special training, high volume of shots
Special preparatory	10.02-20.02.2026	11 days	Maintaining the form, technical and tactical training, recovery after the competition

The subjective indicator is a daily self-assessment on a 10-point scale (0 – «feeling very unwell», 10 – «feeling great, fully ready to work»). This method is a simplified analogue of the Borg scale of perceived stress (Borg CR-10), adapted to assess the overall functional state. The measurements were carried out daily at the same time (in the morning, before the start of training sessions).

The objective indicator is the heart rate (HR, beats /min), measured under standard conditions in the morning after waking up, lying down, for 60 seconds. The measurements were carried out using Polar H10 heart rate monitors, which ensured high recording accuracy. Resting heart rate is considered as a marker of recovery and vegetative tone.

Statistical data processing included the calculation of arithmetic averages, standard deviations, minimum and maximum values. Due to the small sample size and the retrospective nature of the study, no in-depth statistical analysis was conducted, and conclusions were based on qualitative and descriptive analysis.

Results. During the general preparatory period, when the training was mainly of a general physical nature, there was a consistently high subjective assessment of the condition of all athletes. The

average score for the group was 8.4 ± 0.6 points. The minimum values (7 points) were recorded on July 19-20 for one athlete and on July 20 for three more athletes.

Heart rate during this period ranged from 48-73 beats per minute. It is important to note that even on days with minimal subjective estimates, the heart rate did not show critical deviations, remaining within the physiological norm for athletes of this qualification. This is the first sign that subjective sensations may be a more sensitive marker of adverse changes in the state than resting heart rate.

During the period of special training, which included practicing throwing techniques and tactical schemes, the group's subjective scores remained high on average (9.0-9.2 points). However, the analysis shows that some athletes showed a decrease of up to 7-8 points.

Special attention should be paid to the case when, with a subjective score of 10 points (maximum well-being), a heart rate of 72 beats/min was recorded – the highest indicator for the entire observation period, exceeding the average value by more than 12 beats/min. This phenomenon may indicate a dissociation between a subjective sensation and a physiological reaction, possibly related to the individual characteristics of the athlete's body.

Table 2 – Comparative characteristics of subjective and objective indicators in different periods of the annual cycle

Stage of preparation	Number of subjects studied	Average subjective rating (0-10)	Range of subjective ratings	Average heart rate	Heart rate range
General preparatory	7	8,4 ± 0,6	7-10	60,2 ± 4,1	48-73
Special preparatory	7	9,1 ± 0,5	7-10	58,3 ± 3,2	52-65
Special preparatory	7	9,0 ± 0,7	7-10	59,4 ± 4,5	51-72
Special preparatory	8	9,2 ± 0,6	6-10	59,1 ± 4,8	51-67
Pre-competition	8	8,2 ± 1,9	3-10	59,7 ± 3,9	52-75
Special preparatory	7	8,1 ± 1,2	5-10	59,9 ± 4,2	48-70

From the data presented in table 2, it can be seen that the most pronounced decrease in subjective assessments was recorded in the pre-competition period of October 2025. The average score for the group was 8.2 points, but the individual values decreased to 3 points, which is the lowest indicator for the entire follow–up period. At the same time, the average heart rate remained almost unchanged in all periods (58-60 beats per minute), which indicates the absence of a direct correlation between the subjective state and resting heart rate in this sample.

It is also worth noting that during the transition from the general preparatory to the special preparatory period, the subjective scores increased slightly (from 8.4 to 9.1-9.2 points). This may be due to a psychological boost before the start of ice training and a more interesting, varied training program.

The most pronounced decrease in subjective ratings was recorded in the competitive period of October 2025 (average 8.2, but with a drop to 3 points for individual athletes). At the same time, the average heart rate remained almost unchanged in all periods (58-60 beats per minute), which indicates the absence of a direct correlation between the subjective state and resting heart rate in this sample.

The most pronounced decrease in subjective ratings was recorded in the competitive period of October 2025 (average 8.2, but with a drop to 3 points for individual athletes). At the same time, the average heart rate remained almost unchanged in all periods (58-60 beats per minute), which indicates the absence of a direct correlation between the subjective state and resting heart rate in this sample.

Table 3 – Episodes of decreased subjective scores (<5 points) and corresponding heart rate indicators

Date	Period	Athlete's	Subjective assessment	Heart rate	The nature of the ratio
22.10.2025	Pre-competition	№ 1	3	62	Lack of correlation
22.10.2025	Pre-competition	№ 2	3	60	Lack of correlation
22.10.2025	Pre-competition	№ 3	4	60	Lack of correlation
20.10.2025	Pre-competition	№ 3	4	52	Lack of correlation
10.02.2026	Pre-competition	№ 4	5	70	Relative correlation
10.02.2026	Pre-competition	№ 2	5	69	Relative correlation
15.02.2026	Pre-competition	№ 6	5	62	Lack of correlation

As can be seen from Table 3, on October 22, 2025, three athletes estimated their condition at 3-4 points at a normal heart rate (60-62 beats per minute). This is a key episode demonstrating that subjective markers respond to the development of fatigue earlier and with a greater amplitude than resting heart rate.

The data obtained confirm that subjective markers respond to weariness earlier than resting heart rate, which is consistent with the results of Saw et al. [3] and Nuuttila et al. [4]. In October 2025, there was a complete lack of correlation: subjective estimates dropped to critical values with a constant heart rate. This indicates that in the conditions of special preparatory and pre-competitive periods, weariness is mainly psychological in nature and does not affect the vegetative tone at rest.

In February 2026, after a short break, a decrease in subjective assessments was accompanied by an increase in heart rate, which may indicate a physical component of weariness [6].

The Borg scale and its analogues are a valid tool for monitoring weariness in complex coordination sports, as they correlate with objective electromyographic signs of muscle weariness [5].

Discussion. The results of the study showed that in all training periods, the average resting heart rate remained remarkably stable (58-60 beats per minute), despite significant fluctuations in subjective assessments (from 3 to 10 points). This suggests that resting heart rate in the morning is not a sensitive marker of the current functional state in female curlers, at least in conditions of stable vegetative tone.

This conclusion is confirmed in modern studies of heart rate variability. Flatt and co-authors (2024) note that although a decrease in HRV may be a sign of overtraining, this indicator has different information value for different sports and is not always sensitive to the current condition of the athlete [6]. Moreover, in a meta-analysis by Manresa-Rocamora et al. (2021), it was shown that standard resting HRV indicators do not reveal parasympathetic hyperactivity in functionally overtrained athletes, while weekly average HRV values demonstrate a moderate statistical effect [7]. This explains why in this study, one-time measurements of resting heart rate did not reflect the development of fatigue.

An interesting result was the mixed reaction to the decline in subjective assessments in October and February. In October, low scores (3-4 points) were combined with a normal heart rate, which may reflect the so–called «coordination fatigue» - exhaustion of the central nervous mechanisms without involving peripheral energy deficiency. In February, a similar decrease in well-being in some athletes was accompanied by an increase in heart rate, which is closer to the classical physiological response to physical activity [10].

This observation is consistent with the data of Pereira and co-authors (2025), who showed that the development of fatigue leads to significant changes in coordination abilities, while the variability of movements decreases - a compensatory strategy aimed at simplifying the motor task [8]. In curling, where the accuracy of a throw depends on the stability of the body and the consistency of movements, such changes can critically affect performance.

The results of the study confirm the validity of using the Borg perceived stress scale (and its simplified analogues) to monitor the functional state of female athletes in curling. Morishita and co-authors (2022) showed that an increase in perceived tension on the Borg CR-10 scale correlates with objective signs of muscle fatigue recorded by

electromyography [5]. In the context of curling, this is especially important, since the key element of competitive activity is the accuracy of the throw, which can decrease with the development of fatigue in the muscles of the upper and lower extremities, as well as the muscles of the core.

A systematic review by Vasquez-Mercado and co-authors (2024) showed a strong correlation between a subjective assessment of perceived effort and objective methods of monitoring exercise intensity, which confirms the possibility of using subjective scales not only to diagnose fatigue, but also to manage the training process [9].

Based on the data obtained, the following interpretation of subjective estimates on a 10-point scale for curling athletes can be proposed: 9-10 points - excellent condition, normal training regime; 7-8 points – good condition, control without reducing the load; 5-6 points – satisfactory condition, noticeable fatigue, recommended reduction in volume / intensity; 3-4 points – poor condition, severe fatigue, requires a recovery day and medical monitoring; 0-2 points – very poor condition, exhaustion, requires cancellation of training and in-depth examination.

One of the limitations is the lack of data on the psychological status of female athletes (anxiety level, motivation, sleep quality) that could explain individual differences in subjective assessments. The intensity of the training load on each specific day was also not taken into account, which does not allow us to establish a direct causal relationship between the amount of work and the dynamics of markers.

Nevertheless, the practical value of the work lies in the fact that it confirms the need for daily subjective monitoring in curling, especially during periods of special training, when the heart rate can remain normal, and the functional state of the athlete already requires load correction.

Conclusions. Based on the analysis, this retrospective study of the functional state of highly qualified female curling athletes during different periods of the annual training cycle allowed us to formulate the following main conclusions:

1. Higher sensitivity of subjective markers. Subjective markers of fatigue (daily self-assessment on a 10-point scale) are earlier and more sensitive indicators of adverse changes in functional state compared to the objective indicator – resting heart rate. This pattern persists across all studied training periods (general preparatory, special preparatory, pre-competition), confirming the priority of their use in the monitoring system.

2. Period-dependent nature of the correlation. The nature of the relationship between subjective and objective indicators depends on the stage of the annual cycle:

In the *general preparatory period*, the greatest stability of both indicators is observed, reflecting adequate recovery against the background of predominantly general physical training.

In the *special preparatory period*, the most pronounced dissociation was revealed: a decrease in subjective ratings to critical values (3 points) is not accompanied by significant changes in resting heart rate, indicating the formation of «coordination fatigue» of central origin.

In the *pre-competition period*, along with high variability of subjective ratings, their combination with a moderate increase in heart rate is possible, which may reflect the mixed (psycho-emotional and physical) nature of fatigue.

3. Limited informativeness of morning resting heart rate. Single measurements of resting heart rate in the morning hours are not a sensitive marker of the current functional state in highly qualified female curling athletes. The stability of mean heart rate values (58–60 bpm) against the background of a significant decrease in self-assessment (down to 3 points) calls into question the appropriateness of using this indicator as a screening tool for early detection of fatigue in complex coordination sports.

4. Practical validity of the simplified scale. The simplified analogue of the Borg scale (10-point self-assessment scale) is a valid and informative tool for early detection of signs of fatigue in the training process of female curling athletes. The detected episodes of critical decrease in self-assessment (3–4 points) with unchanged hemodynamics justify the need for its daily use, especially during periods of special training when standard physiological markers remain within normal limits.

5. Recommendations for the monitoring system. In the system for monitoring the functional state of curling athletes, priority use of subjective methods (daily morning self-assessment on a 0–10 scale) is advisable, while resting heart rate should be used as an auxiliary marker, primarily for assessing long-term recovery trends rather than operational state.

6. Need for a differentiated approach. The obtained data indicate the need for a differentiated approach to the interpretation of fatigue indicators depending on the training period. A decrease in subjective assessment to 5 points or lower, especially during the special preparatory and pre-competition periods, should serve as a signal for correcting the training load regardless of heart rate values.

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