



## Research paper

# Effect of the menstrual cycle on the muscle strength in young women

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### ABSTRACT

**Introduction:** Nowadays more women are trying to shape their figure properly. Changes in the menstrual cycle can affect the dynamic muscle parameters of women.

**Aim:** The aim of the study was to assess muscle strength in various phases of the menstrual cycle in young women.

**Material and methods:** The study involved 23 women aged 20–22. All the women had menstrual periods ( $27 \pm 3.16$  days). The strength measurement was made by means of Microfet2 (Hoggan Health Industries, USA), which was fixed permanently to the floor. The test was performed on the knee flexors at the angle of  $10^\circ$  and  $90^\circ$  and hip flexors in the neutral position and the glenohumeral joint (shoulder) extensors at the flexion of  $90^\circ$ . The lever arm was marked with the use of anthropometric points. The test was performed three times in each phase of the menstrual cycle; in the early follicular phase (2nd–5th day), the ovular (12th–15th day) and in the luteal phase (16th–28th day).

**Results and discussion:** No statistically significant differences in the muscle torque values during the menstrual cycle were confirmed in the test. The *P* value of the arm extensors is 0.33, for hip flexors is 0.79 and hamstring muscle with a bent knee joint in  $90^\circ$  and  $10^\circ$  is 0.311, 0.567, respectively. No statistically significant differences between the particular cycles phases were confirmed either.

**Conclusions:** In the menstrual cycle in young women, there are no significant differences in muscle strength during the individual phases.

## 1. INTRODUCTION

The menstrual cycle is a cyclical process taking place in the woman's body, depending on many factors related to the functioning of the central nervous system (CNS), endocrine system and the intracellular metabolic processes.<sup>1</sup> The menstrual cycle is a subject of numerous studies, assessing the elasticity and stiffness of ligaments and muscles and the neuromuscular control.<sup>2–6</sup> Considering the more and more frequent participation of women in sports competitions, an increased level of their physical activity and the growing role of workout oriented on body shaping, it becomes necessary to understand the effects which the cyclically changing hormonal system induces upon the properties of skeletal muscles. The results of the research on the effect of sexual hormones on the dynamic properties of muscles are inconsistent. Some of the studies have proven no connection between the muscular strength and menstrual cycle, whereas a part of the studies have proven the existence of such a relation.<sup>7–10</sup> There is an equal number of tests confirming the influence of estrogens on muscles as its lack, which continues to leave this question without an unequivocal answer. The consequence of the difference of the hormones level is a changing rate of women's injuries during the physical activity performed at a particular phase of the menstrual cycle. In the systematic review from 2017 the authors confirm that the frequency of injuries in the luteal phase is significantly lower than in other phases of the menstrual cycle.<sup>11</sup> Furthermore, it has been esteemed that the injuries rate of women within the age range 15–17 and 18–21 is 4–6 times higher than of men.<sup>12</sup> A particular phase of the menstrual cycle may also have an effect on the degree of straining the ligament apparatus, stiffness of the muscle and the neuromuscular activation time.<sup>4</sup>

The changes of estrogen concentration which occur during the menstrual cycle have their reflection in the properties of the muscular tissue. The muscle contraction strength and the maximum voluntary contraction (MVC) is higher and the susceptibility of the muscle tissue to fatigue is lower in the follicular phase, compared to the luteal phase.<sup>5,6,13</sup> The studies on the effect of progesterone on the properties of the muscle tissue prove that a greater oxidation of amino acids and degradation of proteins take place in the luteal phase in comparison to the follicular phase, which is related, to the effect of progesterone on higher catabolism of the proteins, with the estrogens having the opposite effect. The studies confirm the positive correlation of the estrogens concentration level with the development of the maximum muscular strength and an enlarged cross-section of the skeletal muscles. Lowe et al. indicated in his research that the lack of  $17\alpha$ -estradiol in mice caused a decrease of the skeletal strength, whereas the changes in progesterone level were negatively correlated.<sup>14</sup> This can explain the drop of muscular strength in the perimenopausal period. The research has proven that, by  $\alpha$  and  $\beta$  receptors, estrogen can change the structure of muscle tissue influencing the distribution of muscle tissue and stimulate the recovery processes by the

activation and proliferation of satellite cells.<sup>15,16</sup> The same mechanisms takes place in the skeletal muscles cells after the application of a training (strength) stimulus. A part of the scientists explain the influence of estrogens on the improvement of the muscle tissue ability to generate bigger strength by stronger binding of myosin to actin during a contraction.<sup>17</sup> The changes observed during a proper menstrual cycle correlate with the efficiency of physical exercises. Trainings performed in follicular phase of menstrual cycle phase, contribute to increasing the muscular endurance and the diameter of type II muscle fibers.<sup>15</sup> The research has confirmed that women who did not take any oral contraceptives showed a lowered stretch reflex of the rectus femoris muscle during the ovulation phase in opposite to the luteal phase.<sup>18</sup> Though part of research did not confirm the influence of the estrogen – progesterone level on the change of the muscle contraction strength and muscular efficiency, it seems reasonable to consider its influence when preparing strength and endurance training program.

## 2. AIM

The aim of this study was determining the moment of force of muscles in the menstrual cycle.

## 3. MATERIAL AND METHODS

The study involved 23 women aged 20–22 years (an increase of  $167 \pm 6.17$  cm and a BMI of  $20.78 \pm 1.84$ ). None of the respondents took oral contraceptives or received any hormonal treatment during the last year. All women regularly menstruated ( $27 \pm 3.16$  days) for a minimum of 6 months. To determine the phases of the menstrual cycle, information from the subject about the 1st day of menstruation and about the length of the cycle described in the research questionnaire was used. Subjected over a period of 3 cycles, she evaluated the cycle length in the calendar of the menstrual cycle in a mobile application. All tests took place between 9 a.m. to 12 p.m. Each of the participant was asked to eat a light breakfast and limit their activity to 12 h before the test.

Exclusion criteria were:

- women with irregular menstrual cycle or no menstrual period;
- women with a restriction of passive or active mobility in flexion of the hip less than  $120^\circ$ , shoulder less than  $170^\circ$  and knee less than  $120^\circ$ ;
- participants with systemic disorders, including endocrine disorders.

All subjects were informed about the principles of conducting the research and about the risk.

During the Microfet 2 (Hoggan Health Industries, USA) measurement, the values are given in Newtons. In order to unify the results, the lever arm (limb length) were taken into account. Moment of force were calculated in newton metre (Nm) as:

**Table. The assessment of the muscle strength during the menstrual cycle phases.**

Muscles	Follicular phase <i>n</i> (SD)	Ovular phase <i>n</i> (SD)	Luteal phase <i>n</i> (SD)	Menstrual cycle <i>P</i> value
Arm extensors	10.98(1.68)	10.28(2.39)	10.59(2.35)	0.330
Hip flexors	16.30(2.62)	15.89(2.62)	16.15(3.21)	0.797
Hamstring 90°	4.90(1.18)	4.97(1.03)	4.86(0.90)	0.311
Hamstring 10°	5.32(1.10)	5.56(1.25)	5.48(1.20)	0.567

Comments: Analysis of moment of force in individual phases, where the value was expressed in units (Nm). No statistically significant differences were found between three different phases, as  $P > 0.05$ .

$$M = r \times F,$$

were:  $M$  – moment of force,  $r$  – limb length,  $F$  – force.

Static conditions most often use the condition of bone lever balance, determining the moment of force acting in the joint.

Ethical approval for the study was received from the Bioethics Committee of the Silesian Medical University in Katowice (Resolution No. KNW/0022/KB1/26/17), obtained on April 25, 2017. Participation in the research was entirely voluntary. The tests were carried out after obtaining the patient's consent.

Before the test, all the women were asked to fill in the author's research questionnaire which included questions regarding the parameters of their menstrual cycle: its length, course, regularity and occurrence. A given phase of the menstrual cycle was determined on the basis of the obtained answers.

The test was performed on the knee flexors at the angle of 10° and 90° and hip flexors in the neutral position and the glenohumeral joint (shoulder) extensors at the flexion of 90°. The lever arm was marked with the use of anthropometric points. For the arm, the points were the greater tubercle of humerus and the head of the third metacarpal bone. For the leg, the points were marked as the greater trochanter of femur and the lateral malleolus (LM) as well as the greater trochanter up to the head of fibula (HF). In the MVC test with 90° flexion of the knee, the difference between LM and HF was used. Each of the selected muscle can affect women in the menstrual cycle. The hip flexors affect the stability of the pelvic girdle and lumbar region, as do the extensors of the arm on the scapula and shoulder joint. Selected muscle groups have not yet been examined for changes in the menstrual cycle.

In the study, we wanted to check the moment of muscle strength in a variety angle, which is why we gathered the most known muscles group for this purpose. The test was performed 3 times in each phase of the menstrual cycle: in the early follicular phase (2nd–5th day); the ovular (12th–15th day) and in the luteal phase (16th–28th day).

The strength measurement was made by means of Microfet2, which was fixed permanently to the floor. Each participant did a 10 minute warm up before the test and then, in lying on the back position, a steel rod was fixed by means of Velcro tape connecting the tested limb with MicroFet2. The Velcro tape was each time in the same position 10 cm above the ankle for the measurement of the knee and hip flexors and 10 cm proximally from the wrist. Each measurement was made 3 times. Each participant was asked to per-

form an isometric contraction lasting 3 s, with a 15 s break after that. The result was read by another scientists after the performance of tests.

The data obtained in the subsequent research stages were put into the database created in Excel 2012 and subjected to statistical analysis by means of Statistica v. 13.1 program. The ANOVA test was used for the repeatable measurements for dependent groups in order to compare the values of the examined variables in particular phases of the cycle. The assumptions for the normal distribution and sphericity were met. Furthermore, the average values of the examined variables between the phases were compared by means of *t*-Student test for 2 dependent tests. The significance level of  $P \leq 0.05$  ( $P \leq 0.1$  acceptable for a very small group) was assumed.

## 4. RESULTS

Results are shown in the Table.

No statistically significant differences in the muscle torque values during the menstrual cycle were confirmed in the test. No statistically significant differences between the particular cycle phases were confirmed either.

## 5. DISCUSSION

The studies on the menstrual cycle and hormones fluctuation as one of the research aspects connected with the skeletal muscle system have been raising the interest of scientists for a very long time. The research works, although they have been conducted for a very long time, do not provide a clear answer to the question how the sex hormones influence the dynamic parameters of muscles. A part of the studies postulate the lack of such a dependency.<sup>19</sup> The research presenting contrary results indicating the existence of such dependency can also be found. Sarwar et al. (1995) found that the strength of the quadriceps muscle depends on the menstrual cycle; and in 10 women at the age of 19–24 the quadriceps strength was significantly higher during the ovulation phase when the estrogen level was relatively high as compared to the early and mid luteal phase when the said level was significantly lower.<sup>9</sup> In some of the research tests the sex hormones, especially estrogen, do not induce any effect on the growth of muscular strength, which was also confirmed in this analysis. The tests indicate that estradiol does not influence the muscle cross-section, which is visible on

the example of myosin heavy chains (MHC) which do not show any symptoms of isoform expression changes in the course of change of the estradiol concentration level in the menstrual cycle. Estrogen influences rather the structure improving the internal quality of the skeletal muscles upon the neurophysiological effect, in this way the skeletal fibers are capable of generating greater strength.<sup>20</sup> The research of Lowe et al. indicates that myosin fibers are strongly binding to actine during a contraction with participation of estradiol. The influence of this hormone on muscles takes place through estradiol receptors which react to the level of estradiol in skeletal muscles.<sup>14</sup>

In the research conducted by our team no significant changes of the muscle torque for any selected muscle has been recorded. It is worth emphasizing that one of the frequent limitations of the research works, which is also visible in our research, is the fact that the research assumes the same hormonal profile to occur in the examined women on the same days of menstrual cycle. The personal variability of the hormonal profile of healthy women may influence the differences in the results obtained during the tests. While analyzing the obtained results, as well the scientific literature, it can be supposed that the increased level of estrogens, mainly in pre-ovulation phase, does not contribute to increasing the muscular strength but only creates conditions for the improvement of the dynamic properties of muscles. The research proves that while applying the resistance training during the first two weeks of the menstrual cycle there is a bigger increase of the fatless body mass in comparison to the regular training held regardless of the menstrual cycle phases.<sup>17</sup> Similar results were obtained while applying the submaximal resistance which also led to the muscle mass increase.<sup>21</sup> On the other hand, the changing level of hormones concentration has no significant effect on the muscle strength generated in the particular phases of the menstrual cycle.<sup>22</sup> It seems that the adaptation reaction of muscles depending on the cycle phase when the activity is undertaken is of higher significance. Whereas the muscle activity level itself seems to be independent from any changes occurring during the cycle. The strength of the hamstring group was measured in two angle settings, 10° and 90°, whereas the assessment of the influence of the angle setting of the joint on the muscular strength in the menstrual cycle was the additional objective of the test. The muscular strength depends not only on the length of the lever but also on the position of the joint, the optimal length of fibers where the power of contractions is determined by the relationship between the length and the ascending or descending tension.

Strength also depends on the muscle cross-section. There are areas of different length and different cross-section in the structure of a muscle. It means that muscle areas have different relations between their length and tension, so, they will indicate a tendency to produce the maximum muscular strength by different angle settings of the joint.<sup>23</sup> Bell et al. achieved the extensibility of hamstring muscles increased by 8% in the ovulation phase, which might translate into the change of the muscular strength parameter.<sup>24</sup>

These tests were, however, performed on a small group less than 9, whereas one of the estrogen properties is the modulating effect on the reception of pain sensations. The reduced production of estrogen causes lowering the threshold of pain sensation, which may have an effect on the degree of muscle stretching during the experiment.<sup>25</sup>

Also the time of influencing (latency) of the sex hormones upon muscles has an effect on the results. It is not unequivocally determined how much time a hormone needs to induce an effect on the muscle activation. Assuming that sex hormones influence the quality of myosin to actin binding, it has been presumed that a muscle can generate different strength values in different cycle phases at various angle settings. The hamstring muscle group obtains the highest strength values in the range of 30°–90°, reaching its maximum ability at the angle value of 60°.<sup>26</sup> The results obtained in this study confirm the thesis that sex hormones do not influence muscular strength. A natural drop of sex hormones concentration takes place in the perimenopausal period, which is related to a reduced fitness and a gradual decrease of muscle mass. Many women compensate these deficits by an increased intake of exogenous hormones in the form of a hormonal therapy (HT). The studies on the effectiveness of such actions turn out to bring forth unequivocal results also in this case. Skelton et al. obtained in his studies an improvement of the skeletal strength in women in the postmenopausal period.<sup>27</sup> Women undergoing a hormone replacement therapy show greater strength in comparison to the women not using external hormones. However, no changes in strength were recorded while using HT in the Greeves' studies.<sup>28</sup> No increase of muscular strength was found in older women in postmenopausal period performing independent exercises and supplemented with HT during the workout either.<sup>29</sup> Administering exogenous sex hormones did not have any influence on the maximum dynamics and isometric strength in young women.<sup>30</sup> The test results allow to suppose that estrogen does not influence directly the muscular strength by increasing the muscle cross-section; the research of Lee et al. prove, on the contrary, that using oral contraceptives may weaken the increase of muscle mass.<sup>31</sup> The effect of estrogens seems to be more complicated and the manner of inducing an effect on the muscle tissue seems to be more direct than supposed initially.

## 6. CONCLUSIONS

- (1) Our research shows that muscle strength building in programming a training cycle or physical activity can take place throughout the entire unit of the menstrual cycle regardless of its phase. In addition, muscle length does not change the moment of strength in the menstrual cycle.
- (2) The research of the menstrual cycle phase face limitations. It is difficult to determine the hormonal profile of participants, their motivation. The next studies should focus on the influence of sex hormones on the neurophysiological properties of the tested muscles depending on the menstrual-cycle phase.

**Conflict of interest**

None declared.

**Funding**

None declared.

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