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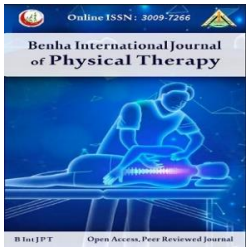

Original research

Correlation between Creatine Phosphokinase and Pelvic Floor Muscle Strength in Postnatal Women

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Abstract:

Background: The pelvic floor muscles are primarily responsible for supporting the visceral organs of the abdomen and for facilitating the passage of urine through the urethral, anal, and vaginal openings. Vaginal deliveries were associated with increased levels of muscle cell damage markers, specifically creatine phosphokinase (CPK), compared to cesarean sections (CSs). **Purpose:** The study aimed to examine the correlation among CPK levels and pelvic floor muscle (PFM) strength within postnatal women. **Methods:** Eighty-four post-partum women who delivered vaginally, (4-6 weeks after delivery), Participants in this study were aged between 25 and 35 years, with a body mass index of fewer than thirty kg/m². **Evaluations:** Blood analysis was done to measure level of CPK and biofeedback (TG Myo Feedback 420v) was utilized to evaluate PFM strength. **Results:** The study's findings revealed that there was a negative correlation (r= -0.226, p= 0.038) among CPK and PFM strength in postnatal women. But CPK and parity were positively correlated (r= 0.230, p= 0.035) in postnatal women. **Conclusion:** CPK is a soft marker that can be used in conjunction with other techniques to determine the PFM strength in postnatal women but it is not a specific indicator for PFM strength.

Key words: Biofeedback, Creatine phosphokinase, Postnatal women, Pelvic floor muscles,

Introduction

The pelvic floor is a complex interrelated structure of muscles, ligaments, and fascia with multiple functions. Among these functions is its formation as a birth canal component, maintenance of continence, assistance with micturition and evacuation, in addition to support of visceral organs[1]. The collection of muscles that provide structural support for the pelvic organs is known as the pelvic floor. The pelvic diaphragm is a hammock-like structure that spans from anterior to the symphysis pubis and posterior to the coccyx posteriorly; it provides supports to the pelvic organs[2].

The prevalence of pelvic floor disorders (PFD) in Egyptian women was estimated previously by mode of delivery and their influence

on patients' quality of life (QOL). The overall prevalence of stress urinary incontinence (SUI) is 38.15%, estimated to be 43.5% for those who gave birth vaginally exclusively, compared to 32.8% in the cesarean section (CS) delivery ≥5 years after the last birth. So, a positive correlation was demonstrated among the mode of delivery and the prevalence of PFD in parous women[3].

According to Nanobashivili et al.[4] and Coelho et al.[5], serum creatine phosphokinase (CPK) levels are a nonspecific indicator of muscle and tissue damage. There is an obvious association among high levels of CPK and extremely intense physical activity, like as running throughout the match, and CPK was previously employed as a measure of muscle fatigue[6]. As a result of direct muscle injury or damage caused by contractions, serum CPK levels can be elevated [7].

Accurate diagnosis of PFDs such as fecal and urinary incontinence, and POP requires an in-depth understanding with the anatomy and physiology of the pelvis and its surrounding structures. Accurate assessment of the pelvic floor and associated conditions is further complicated by the interaction of multiple body systems within the pelvis; the endocrine, gynecologic, urologic, digestive system, neurological, as well as rheumatologic systems are among them[8].

Birth is an event that involves strenuous muscular activity, both for the mother and the neonate; as a result, the CPK levels are expected to be dependent on the level of strenuous activity during the perinatal period. It has been shown that at birth, cord blood CPK activity is raised due to the pronounced muscular activity associated with birth[9].

There have been several studies that point to increased serum CPK activity in the blood of women during labor. According to Khan et al.[9] and AbdRabou[10], these enzymes are believed to be released into the bloodstream during labor by the uterus and placenta, two organs that are known to contain large quantities of these substances and are actively involved in the labor process. It usually takes around six weeks following birth for CPK activity to return to normal[10,11].

By regarding to cesarean section (cs), some research showed that CS known to increase CPK level by the destruction of the myometrial tissue[12]. This is may be explained by Banu et al[13] who concluded that an increasing amount of CPK would give an idea about the damage of the myometrial tissue. By comparing plasma levels of CPK in different types of uterine surgery, it was found that increasing levels of CPK were during uterine abdominal surgery versus laparoscopic surgery[14]. Khan and Rathore[11] also concluded that lower segment CS mode of delivery is associated with increased CPK level.

To the best of our knowledge, no prior research has examined the correlation between postpartum women's pelvic floor muscle strength as well as CPK. Therefore, this study was carried out to establish whether there was a correlation among CPK and PFM strength in post-partum women which might be of value and increase knowledge of obstetricians, physiotherapist and medical health professionals in women's health field.

Methods

Study design:

An observational cross section study was done to determine the correlation among CPK and PFM strength in postnatal women. The duration of this study was 12 months started from May 2023 to May 2024.

Sample Size calculation:

Sample size calculation was performed using G*POWER statistical software (version 3.1.9.2; Franz Faul, Universitat Kiel, Germany) based on the finding of Khaitin et al.[7] who discovered a moderate correlation among CPK levels in the blood and the adductor muscle's maximal isometric strength. This study necessitated a sample size of eighty-four individuals. A power of 80%, a moderate effect size of 0.3, and α=0.05 were used in the calculation.

Participants:

Eighty-four postnatal women were took-part in this study. They were recruited from the outpatient clinic of obstetrics and gynecology, Mataria Teaching Hospital, Cairo, Egypt. All participants were given a full explanation of the procedure and a consent form was signed prior to participation in this study, after clarification the purpose, methods of the study and their rights to withdraw at any time from the study.

Ethics approval and consent to participate:

The study was ethically approved by Institutional board of review from Faculty of Physical Therapy Cairo University prior starting the study [P.T.REC/012/004954], also, the study was prospectively registered at Clinical Trials.gov [NCT06502392].

Inclusion and exclusion criteria:

To be included in the study: Participants were post-partum women who delivered vaginally (4-6 weeks after delivery). They were multiparas' women with a BMI of less than 30 kg/m2 and ages ranging from 25 to 35 years old.

All participants were screened for potential pathological disorders that could impact the results of the investigation, including cardiac problems. Those with any dysfunction, related injuries, or pathological conditions were excluded participating in the study[15], thyroid dysfunction16, recurrent urinary tract infections, pelvic infection[17], uncontrolled hypertension[18], or diabetes mellitus[19], history of pelvic inflammatory disease[20], myoma and tumors[21], a cyst in the ovaries, a gynecological disorder, a defect of hormones[20], a psychological condition[22], or difficulty understanding written and verbal instructions

Procedures:

Before participating in this study, each lady had a full medical history and recorded in a recording data sheet. Each woman was instructed carefully about the study protocol to gain their cooperation throughout the study. The next step was to determine each woman's body mass index (BMI) by measuring her height and weight while she was barefoot and wearing loose clothing based on the following equation: BMI (kg / m2) = Weight (kg) / Height 2 (m2)[23]

Evaluation procedures:

a) Blood analysis:

The venous blood sample was collected from brachial vein from all women within all precautions. The sterile vacutainer tubes were filled with 9 mL of blood and anticoagulant before being symmetrically inserted into the centrifuge apparatus[24]. Instantly, the serum was extracted from the blood and placed in epindoorf tubes[25] for analysis using kits (CK-NAC, opt. DGKC/IFCC kits; made in Austria), to measure CPK level for all participating post-partum women through using Vitros 350 (Ortho Clinical Diagnostic, Inc.), made in Rochester, NY 14626-5101, with model number ET1529L-7SWA-1-RNBCG. The normal values of CPK total (24-170 U/L) [10].

b) Assessment of PFM strength:

All postpartum women had their PFM strength and endurance tested using biofeedback (TG Myo Feedback 420v). To perform this, we had them lie down in a comfortable crook lying position using a pillow behind their heads and little cushions beneath their lower back and hips. Carefully insert the KY gel-lubricated TG Myo feedback 420v vaginal electrode into the vagina after it had been washed and covered with a condom allowed us to measure the vaginal closure pressure by way of the deeper internal PFM strength. Using the internal probe, any woman can improve her proprioception and become more aware of her muscles[26].

This is followed by a description of the TG Myo feedback screen for the women. Start using a wristwatch to time a 1-minute resting baseline. For a more accurate baseline reading, it is best to keep conversation to a minimum and avoid interruptions throughout the evaluation. Hypertonicity or failure to relax the PFM is indicated by an inconsistent baseline resting tone. It might also be a sign of neuromuscular incoordination or a problem differentiating between tense and relaxed muscles. The women were instructed to firmly squeeze the PFM around the electrode for 10 seconds before releasing the tension; this process was repeated three times. The data sheet was then updated with the calculated mean of the three readings[26]. Muscle strength, defined as the maximum force that can be applied and maintained during a contraction, and endurance, defined as the amount of time it takes for a submaximal contraction to be maintained or repeated until a 50% loss in power is observed, are two distinct variables[2].

Data Analysis

The results are presented as means with standard deviations, minimums and maximums. Utilizing the Pearson correlation coefficient, we investigated for a correlation among CPK, PFM strength, as well as parity in post-partum women. The statistical analysis was carried out using the Windows version 19 of the Statistical Package for the Social Sciences (SPSS) software. A significant result was defined as a P value < 0.05.

Results

Subject characteristics:

Initially, 95 people were assessed for eligibility. Five of them were not met the inclusion criteria and another 6 of them refused to participate in the study. So, 84 participants were included and analyzed **(Fig. 1).**

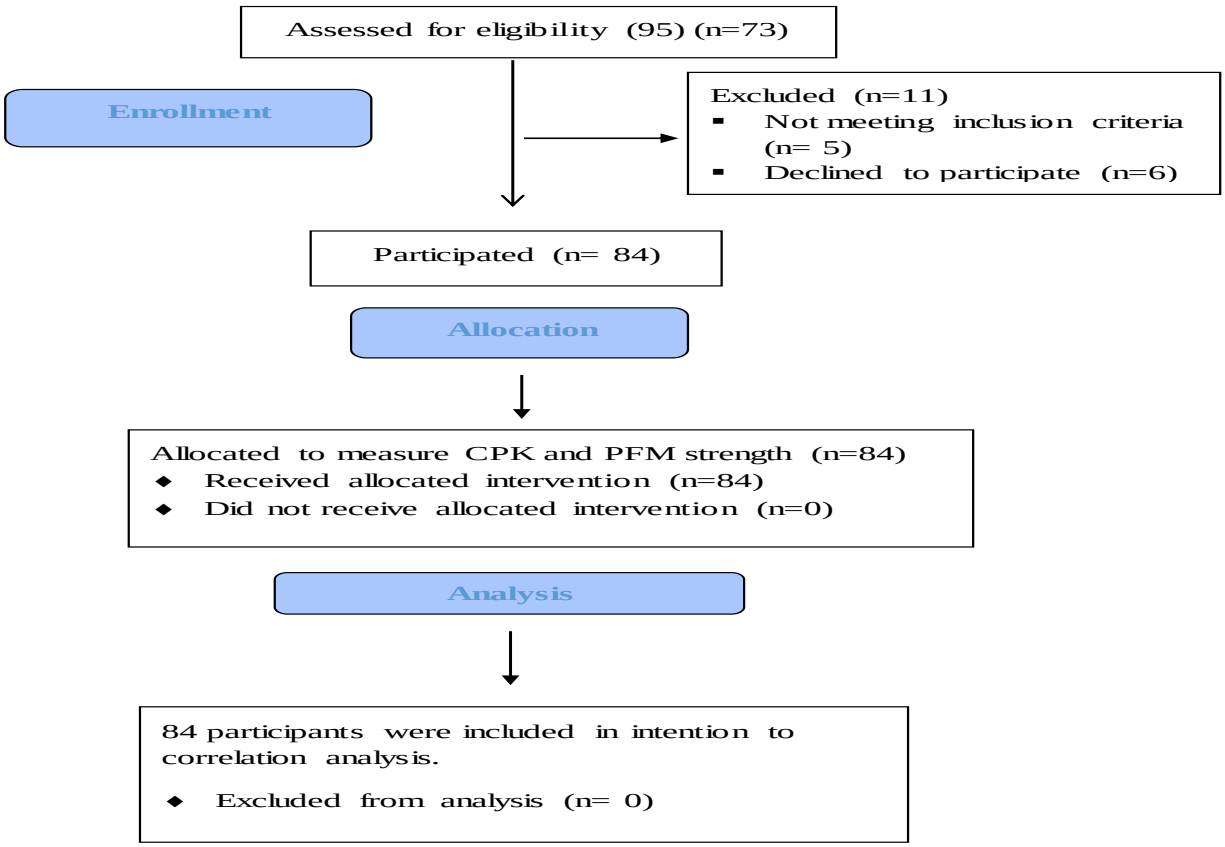

Fig. (1): flow chart of the study

Table (1): Demographic features (general characteristics):

	Minimum	Maximum	Mean	Standard deviation
Age (yrs.)	24.00	35.00	31.36	2.24
Weight (kg.)	60.00	95.00	76.04	7.19
Height (cm)	1.50	1.82	1.66	0.06
BMI (kg/m^2)	23.50	29.90	27.64	1.50
Parity (child)	2.00	5.00	3.31	0.93

There was a negative correlation between CPK and PFM strength (r= -0.226, p= 0.038), but there was a positive correlation among CPK and parity (r= 0.230, p= 0.035).

Table (2): Correlation between CPK and PFM strength; and parity:

	Pelvic floor muscle strength		Parity	
	Correlation coefficient	P value	Correlation coefficient	P value
CPK	-0.226	0.038*	0.230	0.035*

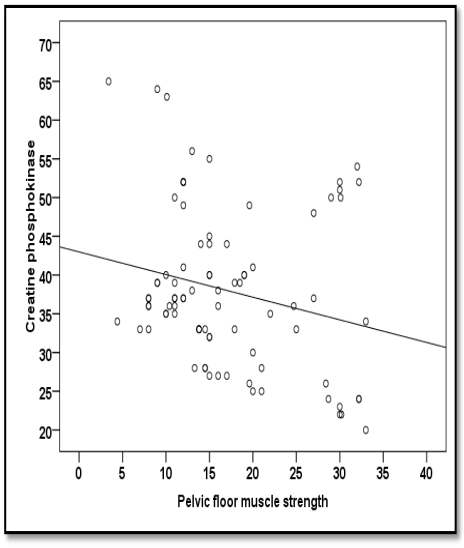

Fig. (2): Correlation between CPK and PFM strength in post-partum women (r= -0.226, p= 0.038)

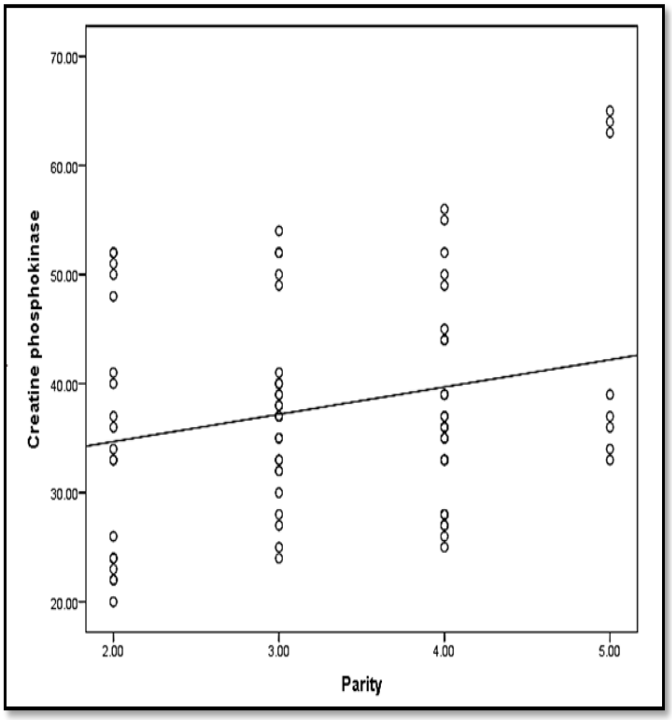

Fig. (3): Correlation between CPK and parity in post-partum women (r= 0.230, p= 0.035)

Discussion

Pelvic floor problems have a complex and multifactorial pathophysiology that affects women's health[27]. There are a number of sociodemographic characteristics that increase the possibility of developing PFD, including advanced age, gastrointestinal disease, previous vaginal deliveries, as well as instrumental vaginal births[28].

As the uterus grows in size throughout pregnancy, it puts an excessive strain on the perineal structures. The parties appear and pass through the urogenital hiatus during delivery, which increases the pressure on the tissues and causes the pelvic floor to strain, possibly resulting in injury to the muscles, connective tissue, and/or nerves. According to Fonti et al.[29] the majority of women undergo pelvic floor trauma after vaginal birth, which can lead to significant damage to the muscular tissue. The levels of CPK, a measure of muscle cell injury, were greater in vaginal deliveries (both spontaneous and surgical) compared to CS30.

The present study was conducted to investigate the correlation among CPK and PFM strength; and parity in post-partum women.

The findings of this study showed that there was a negative correlation among CPK and PFM strength but on the other side, there was a positive

correlation between CPK and parity in postnatal women.

According to our knowledge, there was no related review directly correlate CPK level with PFM strength. So, we try to support its association with muscle strength through the following studies.

Wang et al.[31] found that changes in skeletal muscle mass[32] may affect CPK concentrations. During periods of intense activity, its concentrations typically rise above normal levels and do not recover to normal levels for three to four days[33].

Previous studies confirmed that post-exercise CPK changes are closely associated to maximal isometric strength[34], and maximum isometric strength immediately after eccentric exercise is negatively associated with peak CPK activity[35].

The perineal structures are put through an excessive strain throughout pregnancy due to the uterus's gradual volume expansion. The parties appear and pass through the urogenital hiatus during delivery, which increases the pressure on the tissues and causes the pelvic floor to strain, possibly resulting in injury to the muscles, connective tissue, and/or nerves. According to Fonti et al.[29] the majority of women undergo pelvic floor trauma after vaginal birth, which can lead to significant damage to the muscular tissue.

Both the mother and the newborn use their muscles extensively throughout labor and delivery. The mother controls the uterus's contractions, the supra-umbilical diastasis, as well as the mother's voluntary abdominal pushes; fetal influences include the fetus's position, its presentation throughout labor, and its cephalic circumference. Any one of these may cause CPK levels to rise[36].

There have been multiple reports of increased serum CPK activity in the mother's blood during childbirth. It is believed that these enzymes are released into the circulation during labor by the uterus as well as placenta, two organs that contain a significant quantity of these enzymes and take an active role in the process[9].

Banu et al.[13] found no evidence of myometrial ischemia or necrosis after uterine artery embolization procedures but rising serum CPK isoenzyme levels suggest myometrial tissue damage. The study quantified markers of inflammation, ischemia, along with necrosis in women experiencing uterine artery embolization.

In the study of AbdRabou[10] who studied evaluation of CS scar using maternal serum level of creatine kinase isoenzyme (CPK-MB) prior to delivery, and reported that CK-MB can be used as a soft marker beside other methods for detection of CS abnormality prior to delivery with high sensitivity and specificity.

Furthermore, McNeely et al.[37] measured the serum CPK activity of 28 women having normal pregnancies at six-time intervals to examine CPK and its isoenzymes in women's serum during pregnancy as well as the peripartum period. As a whole, the CPK activity was 29 U/L in the 3rd trimester, 45 U/L from 30–36 weeks gestation, 109 U/L upon labor hospital admission, 132 U/L in the first 30 minutes after delivery, 49 U/L from 7–9 hours following delivery, and 35 U/L on the 5th day after after delivery. This indicates that CPK activity begins to climb as the delivery time draws near, reaching a peak between seven- and nine-hours following birth. In most cases, the CPK activity returns to normal within six weeks of giving birth.

The CPK isoenzyme activity followed a similar pattern; Khan and Rathore11 found a strong correlation between the mode of delivery as well as serum CPK activity; total CPK levels rose significantly throughout labor, peaking at 2-4 times baseline levels 24 hours after birth. Afterwards, it progressively returned to its initial level. There was a significant difference in the levels attained by nulliparous and multiparous women. An essential component to the CPK surge in the majority of women was determined to be the CPK-MB, which is present in significant amounts in the uterus and placenta. When there is no sign of myocardial ischemia and the pregnant woman is going through a normal vaginal delivery, the levels of serum total CPK and the MB isoenzyme rise significantly[38].

In addition, Leiserowitz et al.[39] recruited 49 healthy pregnant women at the end of the 3rd trimester and measured their CPK levels four times over the course of the pregnancy and reported that creatine kinase –MB (CK-MB) is found not only in myocardium but also in uterus and placenta. Findings from their study suggest that peripartum CK and total CK increases should be utilized with caution when diagnosing myocardial ischemia or infarction[40].

In addition, Asgharnia et al.[41] found that when the zygote implants are positioned next to the

fallopian tube's muscle layer, there is a rise in the level of CPK, which is a marker for soft muscle injury, similar to tubal ectopic pregnancy.

Changes in CPK increased significantly during the reperfusion phase (e.g., from delivery to 1 hour postpartum) in the study by Conner et al.[30]. Furthermore, the level of CPK during the reperfusion phase was significantly elevated when the ischemia period was longer (for example, when the 2nd stage of labor was significantly longer).

This study's findings on the correlation among CPK and parity are in line with those of Paterson and Lawrence42, who found that factors such as aging alcohol consumption, oral contraceptive consumption, marital status, parity, as well as oral contraceptive intake significantly affected serum CPK concentrations in normal adult females.

However, Safdarian et al.[43] found no significant correlation between CPK and age, gravidity, or parity when they evaluated plasma CPK levels following just one administration of methotrexate as a predictor of treatment success in ectopic pregnancies. These findings contradict the current study's results.

Strength and limitations:

Till now, there is no previous study investigated the correlation between CPK level and PFM strength in postnatal women. So, this study would be the first one in this issue. Also, Sample size calculation was performed using G*POWER statistical software (version 3.1.9.2; Franz Faul, Universitat Kiel, Germany) based on the finding of Khaitin et al.,[7] who discovered a moderate correlation among CPK levels in the blood and the adductor muscle's maximal isometric strength. This study necessitated a sample size of eighty-four individuals. A power of 80%, a modest effect size of 0.3, and α=0.05 were used in the calculation.

However, there were some limitations of the study as physical, psycological, socioeconomic and environmental might affect the results of the study in addition to co-operation of female in conducting the procedures and their cutural level variations.

Conclusion

This study concluded that there is negative correlation among CPK and PFM strength and positive correlation among CPK and parity and this conclusion refers to CPK is an indicator of muscle tissue injury or damage as in labor and postnatal periods, and its magnitude correlates with the extent of muscle damage and monitoring the progression or resolution of muscle injury.

DECLARATIONS

Consent to publish: I certify that each author has given their consent to submit the work.

Competing interests: None.

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References

1. Martellucci J, Bergamini C, Palla G, Simoncini T, Naldini G, Valeri A. Functional anatomy of the pelvic floor. InElectrical Stimulation for Pelvic Floor Disorders 2014 Aug 11 (pp. 19-42). Cham: Springer International Publishing.
2. Cho ST, Kim KH. Pelvic floor muscle exercise and training for coping with urinary incontinence. Journal of exercise rehabilitation. 2021 Dec 27;17(6):379.
3. El Kady OS, Tamara TF, Sabaa HA, Hafez AH. Assessment of the prevalence of pelvic floor disorders in both vaginal and cesarean deliveries and their impact on the quality of life. The Egyptian Journal of Hospital Medicine. 2017 Jul 1;68(2):1252-6.
4. Nanobashvili J, Neumayer C, Fügl A, Punz A, Blumer R, Prager M, Mittlböck M, Gruber H, Polterauer P, Roth E, Malinski T. Ischemia/reperfusion injury of skeletal muscle: plasma taurine as a measure of tissue damage. Surgery. 2003 Jan 1;133(1):91-100.
5. Coelho DB, Cabido CE, Ciminelli VA, Coelho LG, Becker LK, Oliveira EC, Pereira ER, Marins JC, Garcia ES. Comparison of different ways of expressing creatine kinase concentration of soccer players during a competitive season. Motriz: Revista de Educacao Física. 2016 Jul;22:160-5.
6. Hader K, Rumpf MC, Hertzog M, Kilduff LP, Girard O, Silva JR. Monitoring the athlete match response: Can external load variables predict post-match acute and residual fatigue in soccer? A systematic review with meta-analysis. Sports medicine-open. 2019 Dec;5(1):48.
7. Khaitin V, Bezuglov E, Lazarev A, Matveev S, Ivanova O, Maffulli N, Achkasov E. Markers of muscle damage and strength performance in professional football (soccer)

players during the competitive period. Annals of translational medicine. 2021 Jan;9(2):113.
8. Rana N, Drake MJ, Rinko R, Dawson M, Whitmore KE. The fundamentals of chronic pelvic pain assessment, based on international continence society recommendations. Neurourology and urodynamics. 2018 Aug;37(S6):S32-8.
9. Khan A, Rathore B, Singh K, Singh M, Misra A. Association of creatine kinase and its isoenzymes (CK-MB, CK-BB) activity with high risk pregnancy. Int J Res Med Sci. 2017 Apr;5(4):1464-70.
10. AbdRabou IM. Evaluation of Cesarean Section Scar Using Maternal Serum Level of Creatine Kinase Isoenzyme (Ck-Mb) Prior to Delivery. Evidence Based Women's Health Journal. 2021 Aug 1;11(3):219-25.
11. Khan A, Rathore B. Total Creatine Kinase And Its Isoenzymes In Cord Blood Of Full Term Newborns. EJMR. 2017 Jan 1;4(1):10-21.
12. Turan GA, Gur EB, Tatar S, Gokduman A, Guclu S. Uterine closure with unlocked suture in cesarean section: Safety and Quality. Pak J Med Sci. 2014 May;30(3):530-4.
13. Banu NS, Gaze DC, Bruce H, Collinson PO, Belli AM, Manyonda IT. Markers of muscle ischemia, necrosis, and inflammation following uterine artery embolization in the treatment of symptomatic uterine fibroids. Am J Obstet Gynecol. 2007 Mar;196(3):213.e1-5.
14. Essone JN, Abessolo FO, Tsagoulela A, Nkhilli GE, Assoumou P, Ntamack JB, Anyunzok E, Minkobame U, Meye JF, Milama EN. Uterine Reperfusion Ischemia and Use of Elastic Tourniquet. Journal of Biosciences and Medicines. 2019 Feb; 7(2): 98-119.
15. Morandi L, Angelini C, Prelle A, Pini A, Grassi B, Bernardi G, Politano L, Bruno C, De Grandis D, Cudia P, Citterio A. High plasma creatine kinase: review of the literature and proposal for a diagnostic algorithm. Neurological Sciences. 2006 Nov;27:303-11.
16. McGrowder DA, Fraser YP, Gordon L, Crawford TV, Rawlins JM. Serum creatine kinase and lactate dehydrogenase activities in patients with thyroid disorders. Nigerian journal of clinical practice. 2011;14(4):454-9.
17. Chatzizisis YS, Misirli G, Hatzitolios AI, Giannoglou GD. The syndrome of rhabdomyolysis: complications and treatment. European journal of internal medicine. 2008 Dec 1;19(8):568-74.
18. Johnsen SH, Lilleng H, Wilsgaard T, Bekkelund SI. Creatine kinase activity and blood pressure in a normal population: the Tromsø study. Journal of hypertension. 2011 Jan 1;29(1):36-42.
19. Banik S, Das M, Aich A, Bhattacharyya G, Bardhan ON, Devi RS, Das RN. Impacts of Serum Creatinine Phosphokinase on Heart, Diabetes and Anaemia Patients. Journal of Community Medicine and Public Health. 2024 May17; 8(2): 436-46.
20. Chandra L, Jain A. Maternal serum creatine kinase as a biochemical marker of tubal pregnancy. International Journal of Gynecology & Obstetrics. 1995 Apr 1;49(1):21-3.
21. Nakamura Y, Ito K, Takemura N, Inagaki F, Mihara F, Kokudo N. Elevation in creatine kinase isoenzyme-MM associated with hepatocellular carcinoma: a case report and review of literature. Clinical Journal of Gastroenterology. 2022 Apr;15(2):460-6.
22. Allen PJ. Creatine metabolism and psychiatric disorders: Does creatine supplementation have therapeutic value?. Neuroscience & Biobehavioral Reviews. 2012 May 1;36(5):1442-62.
23. Nuttall FQ. Body mass index: obesity, BMI, and health: a critical review. Nutrition today. 2015 May 1;50(3):117-28.
24. Tehranchi A, Behnia H, Pourdanesh F, Behnia P, Pinto N, Younessian F. The effect of autologous leukocyte platelet rich fibrin on the rate of orthodontic tooth movement: a prospective randomized clinical trial. European journal of dentistry. 2018 Jul;12(03):350-7.
25. Huang X, Zhuang Z, Frenkel K, Klein CB, Costa M. The role of nickel and nickel-mediated reactive oxygen species in the mechanism of nickel carcinogenesis. Environmental health perspectives. 1994 Sep;102(suppl 3):281-4.
26. Hassan Emara DM, Mohamed Awad MA, Botla AM, Gabr AA. Effect of labor on pelvic floor muscles strength. Egyptian Journal of Physical Therapy. 2020 Mar 1;1(1):8-13.

27. Ge J, Wei XJ, Zhang HZ, Fang GY. Pelvic floor muscle training in the treatment of pelvic organ prolapse: A meta-analysis of randomized controlled trials. Actas Urológicas Españolas (English Edition). 2021 Jan 1;45(1):73-82.
28. Peinado-Molina RA, Hernández-Martínez A, Martínez-Vázquez S, Rodríguez-Almagro J, Martínez-Galiano JM. Pelvic floor dysfunction: prevalence and associated factors. BMC public health. 2023 Oct 14;23(1):2005.
29. Fonti Y, Giordano R, Cacciatore A, Romano M, La Rosa B. Post partum pelvic floor changes. Journal of prenatal medicine. 2009 Oct;3(4):57.
30. Conner E, Margulies R, Liu M, Smilen SW, Porges RF, Kwon C. Vaginal delivery and serum markers of ischemia/reperfusion injury. International Journal of Gynecology & Obstetrics. 2006 Aug 1;94(2):96-102.
31. Wang Z, Du W, Han M, He L, Zhang H, Hu J, Quan R. Association between creatine phosphokinase level within normal range and bone mineral density in adolescents. Medicine. 2023 Aug 11;102(32):e34724.
32. Alexopoulos T, Vasilieva L, Kontogianni MD, Tenta R, Georgiou A, Stroumpouli E, Mani I, Alexopoulou A. Myostatin in combination with creatine phosphokinase or albumin may differentiate patients with cirrhosis and sarcopenia. American Journal of Physiology-Gastrointestinal and Liver Physiology. 2021 Nov 1;321(5):G543-51.
33. Kumar R, Kumar S, Kumar A, Kumar D, Kumar V. Exercise-induced rhabdomyolysis causing acute kidney injury: a potential threat to gym lovers. Cureus. 2022 Aug 15;14(8).
34. Kim J, Lee J. The relationship of creatine kinase variability with body composition and muscle damage markers following eccentric muscle contractions. Journal of exercise nutrition & biochemistry. 2015 Jun 30;19(2):123.
35. Nosaka K, Chapman D, Newton M, Sacco P. Is isometric strength loss immediately after eccentric exercise related to changes in indirect markers of muscle damage?. Applied physiology, nutrition, and metabolism. 2006 Jun 1;31(3):313-9.
36. Oliveira BD, Andrade AD, Lemos A, Brito VC, Pedrosa ML, Silva TN. Abdominal muscle electrical activity during labor expulsive stage: a cross-sectional study. Brazilian Journal of Physical Therapy. 2011;15:445-51.
37. McNeely MD, Baerris B, Papsin FR, Lyons E, Schipper H. Creatine kinase and its isoenzymes in the serum of women during pregnancy and the peripartum period. Clinical chemistry. 1977 Oct 1;23(10):1878-80.
38. Abramov Y, Abramov D, Abrahamov A, Durst R, Schenker J. Elevation of serum creatine phosphokinase and its MB isoenzyme during normal labor and early puerperium. Acta obstetricia et gynecologica Scandinavica. 1996 Jan 1;75(3):255-60.
39. Leiserowitz GS, Evans AT, Samuels SJ, Omand K, Kost GJ. Creatine kinase and its MB isoenzyme in the third trimester and the peripartum period. The Journal of reproductive medicine. 1992 Nov 1;37(11):910-6.
40. Torabi Z, Salmani R, Fayaz A, Ahmadiafshar A. Comparative levels of total creatine kinase and MB-isoenzyme in cord blood between vaginal delivery and cesarean section. International Journal of Biochemistry Research & Review. 2014;4(4):306-11.
41. Asgharnia M, Faraji R, Mirblouk F, Roshan ZA, Parvizi A. Evaluation of serum creatine phosphokinase in diagnosis of tubal ectopic pregnancy compared with intrauterine pregnancy and threatened abortion. Iranian journal of reproductive medicine. 2012 Jul;10(4):303.
42. Paterson Y, Lawrence EF. Factors affecting serum creatine phosphokinase levels in normal adult females. Clinica Chimica Acta. 1972 Nov 1;42(1):131-9.
43. Safdarian L, Aghahosseini M, Alleyassin A, Kohbodi M. Evaluation of plasma creatine phosphokinase (CPK) level following a single injection of methotrexate as a predicator of treatment success in ectopic pregnancy. Journal of Family & Reproductive Health. 2013 Dec;7(4):151.