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KNEE extension lag: A review

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***Abstract*---**In a study involving 34 patients, researchers looked at how knee extension lag correlated with other measures of injured and healthy limbs. The average flexion force was found to be greater than the average extension force in the injured extremity, and there was no difference between the means of flexion and extension force. This study also found that the extension lag was unrelated to squatting depth, extension force, flexion force, circumference at the joint line, circumference 5 and 15 centimeters cephalad to the patella pole, and active or passive knee flexion. When compared to a control group of patients with healthy rotational movements, these medians showed significant variation. Comparisons between patient groups suggest a connection between quadriceps weakness and knee extension lag, but no other factors have been found to correlate with this finding. Researchers recommend recruiting participants with extension lags greater than 30 in order to increase the likelihood of discovering such links.

***Keywords*---**knee, extension lag, flexion force, extension force, joint line.

Introduction

One of the goals of physical therapy for knees that have been injured or surgically repaired is to eliminate extension lag (EL). Disparity between the active and passive knee extending ranges characterizes EL. Since EL suggests that factors other than the ineffectiveness of the quadriceps muscles are to blame, it is preferred over quadriceps lag. “Muscle lag,” “extenser interval,” and “quadriceps

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lags" have all been in use for at least 40 years now. When the knee's active range of motion is less than its passive range of motion, this condition is known as knee extensor lag. To emphasize that factors other than muscle function may contribute to the problem, we refer to this phenomenon as extension lag rather than quadriceps lag. Muscle atrophy, stiff joints, and pain are all possible causes of extensor intervals. Patients with extension lag require assistance in straightening their knee. Patients with extension lag have trouble slowing down because of their restricted knee flexion. The inability to achieve full range of motion in a joint is a hallmark symptom of muscle laziness. Strive for passive limits that require minimal effort and can be achieved despite the resistance of joint stiffness or other soft tissue tightness (Oliva F, 2021).

The thigh bone is the attachment point for all four of your quadriceps muscles (femur). The femur is the starting point for three of the four (the long bone in the upper thigh). The inner front of the thigh is occupied by the vastusmedialis muscle, the outer side by the vastus lateralis, and the middle by the vastus intermedius. The rectus femoris, the fourth major thigh muscle, lies above the vastus intermedius and travels medially down the thigh (B. Bijish Kumar., 2016). All four of the leg's muscles attach to the kneecap via the quadriceps ligament, which begins at the skin of the forearm right below the prominent iliac spine. The patella is inserted into the top of the tibia with the help of a sturdy patellar tender. As a result of a contraction of the quadriceps muscles, there is increased knee stability (Bonnin M, 2016). For nails in which the quadriceps totally fix the knee, as in Standing positions with straight legs and posture and detected in the front twist, this occurs along the thighs and knees, with all the work being done on the spot. On the other hand, the quadriceps isn't the only muscles used in the packaging process. You'll always be walking around with your knees cocked. The rectus femoris muscle squeezes the inner and outer thighs together when the knee is extended. It should aid in keeping the knee straight along with the other hip flexors and the other three quad muscles (Coraci D, 2016).

Knee extension

To encourage knee extension, have the patient lie supine on the plinth. The next step is to adjust the plinth's height such that a fully extended knee forms a right angle with the floor. Then, fasten the seat belt around the thighs and lay the towel at the very tip of the femur shaft, above the patella (Jette DU, 2020). After that, the plinth needs to be raised little by little until the right amount of supported power is being used to fully extend the knee. The author recommends a time frame of 1-2 minutes, which, depending on patient tolerance, can be increased to 5 minutes. If the patient needs more than zero degrees of ankle flexion or extension, the foam roll can be slid beneath the foot (Kumar R, 2020).

Kneeling

Sleeping with a cushion beneath the patient's stomach and a towel wrapped over the shoulder and ankle can assist them keep their knees bent while they rest. After that, you'll need to use two binding straps to fasten the patient to the plinth by tying one end around the ankle and the other end over the shoulder. Physiotherapists typically extend the plinth's size by a minimal amount to allow for flexions between 10 and 120 degrees. Furthermore, the timeline will be similar to that of regaining knee extension, and the rate of improvement will be dependent on the patient's tolerance for prolonged energy. Consider this your formal invitation if you're interested. For a fee (ROM) and the use of a single boost band attached to the table in place of the patient's shoulder, the ROM can be increased to more than 120 degrees (Kumar R, 2020).

In another case study, Douglass found that after patellar tendon repair, Graston's method of releasing the soft tissue connection behind the knee arthrofibrosis greatly improved range of motion (ROM) and quadriceps function. By employing stainless steel devices, Graston's approach can stimulate the soft tissues (Maffulli N, 2017). The metals are reshaped after the removal of any red tissue, adhesions, or imposing borders. An incompatible lubricant is utilized to induce local hyperemia, analgesia, a fibroblastic response, and treatment. Stimulation of the patellar and quadriceps muscles on the day of operation, together with range-of-motion Standard physiotherapy care was supplemented with GT in this case study, which included continuous passive motion (CPM) for 2–6 hours daily beginning 7 days after surgery, joint stimulation (30 removals), current disruption and ice pack for edema and pain control, and a home exercise regimen (Lim CT, 2017).

Within 5 weeks of treatment, the patient's range of motion improved by 28 degrees thanks to a single intervention. The patient's active ROM was increased by 17 degrees, and their extensor latency was decreased by 19 degrees, allowing them to fully imitate without the use of any assistance or braces, even in microgravity (Maffulli N, 2017). A systematic analysis of controlled studies conducted by Joseph et al. indicated that postoperative therapies such as strenuous exercise, water treatment, balancing the balance, and the clinical nature of reducing disability after TKA were effective. Patients in the research ranged in age from 65 to 73, and they underwent either a unicompartmental or total knee replacement. The author conducted a meta-analysis and found that regular strengthening of NMES led to greater increases in quadriceps strength than did a single RCT study in which participants received only practical training in routine updates. Improvements in the 6-minute walk, bone marrow west of Ontario with McMaster, and pain rating were measured at 4 and 6 months post-TKA, proving the effectiveness of the revitalization program (Makino Koji. 2016).

In their study, Evgeniadis and coworkers after eight weeks of treatment, patients who were given both the knee brace and patient rehabilitation reported greater knee flexion and range of motion compared to those in the control group who had only received patient rehabilitation. Water-based exercise programs were found to be particularly effective, with Valtonen et al. reporting significant improvements in knee flexion and extension strength, walking speed, and stair climbing ability after 12 weeks of training compared to trials in which no exercise interventions were found (Makino Koji. 2016). Piva et al. discovered that after 6 weeks of equilibrium, productivity increased. Improvements in gait speed (by 8 percent) and unilateral limb impairment (by 24 percent) were both recorded after the correction program was implemented. Based on a review of the relevant literature, the authors conclude that home-based, emergency patient (clinically based), and telerehabilitation system (TRS) rejuvenation all lead to comparable increases in range of motion (ROM), extensor strength (ES), gait speed (GT), motion test (MT), and knee extension torque (KET) after 12 months (Patra Anirban, 2018).

Cook and Rudavasky conducted a meta-analysis to determine the efficacy of physiotherapy in reducing pain, boosting strength, and preventing further complications from patellar tendinopathy. The author postulated that 45 seconds of continuous isometric friction, repeated twice a day, four times a week, would have a significant hypoalgesic effect. Strength training with slightly heavy (isotonic) resistance in sets of 4, 6-8 repeated 3-5 times per day, weight loss, walking up stairs, breaking banknotes, running up stairs, or skipping exercises are all good options (Papagiannis GI, 2016). Tendinopathy of the knee can be treated with a six-week program of endurance exercises, including energy-saving cardio, concentric and eccentric strengthening, and plyometrics at a high intensity.

Objectives

- The goals of this research were to examine the connection between knee EL and other factors.
- To determine the relationship between active range of knee flexion, discomfort, and isometric muscular force of knee extension and knee flexion
- Find the causes and potential treatments for EL by analyzing the data.

Review of literature

Oliva F, et al. (2021). As per his research Physical therapists may provide an idea of a rehabilitation paradigm for increasing knee flexion after surgery, but there is no universally accepted method. The purpose of the following research is to provide some indication of whether or not physiotherapy plays a significant effect in reducing postoperative pain; it does not address the caveats involved with employing certain renewal processes. Jette DU, et al. (2020). Synthesized evidence showing the benefits of physiotherapy both before and after total knee replacement. The study reevaluated the use of neuromuscular block Electricity Promotion (NMES) before and after exercise to increase quadriceps back muscle strength in patients who had undergone total knee replacement surgery; however, its limitations should be taken into account.

At 3.5 weeks post-surgery, quadriceps, muscle strength that strengthens muscles, and range of motion (ROM) were all considerably improved after NMES was delivered twice daily with 15 pushes. Kumar R, et al. (2020). Addressed about Whole-body vibrations have been shown to increase muscular strength, increase range of motion, and manage postoperative weakness in patients of varying severities in randomized controlled studies and clinical trials. Other methods explored in the literature include continuous movement (CPM), in which motorized equipment from the outside is used to move the knee in accordance with a predetermined arc of motion. Researchers showed that individuals who received CPM immediately in the recovery room following TKR had greater gains in performance and input flexion range of motion than those who received CPM the day after surgery. Comprehensive reviews have shown that CPM has a modest, temporary, and functional effect on flexion ROM, but no evidence that treatment has any lasting effects on active or functional knee extension ROM, pain, edema, or quadriceps strength. Wood TJ, et al. (2019). Addressed about patients who have had hydrotherapy in the six months following a total knee replacement (TKR) has reported significant reductions in pain, stiffness, and functional impairment.

Two systematic reviews found that using cryotherapy on day 2 following surgery reduced blood loss, improved pain management, reduced edema, and increased knee flexibility. In addition to your own experience, the results of two randomized controlled trials on people who had undergone total knee arthroplasty (TKA) revealed that treatment with pulsed electromagnetic fields (PEMF) reduced pain and inflammation one month after surgery. Wise BT, et al. (2018). His analysis to improve knee flexion and range of motion, Shah suggested an innovative and effective alternative strategy in his article. After arthroscopic knee surgery, ACL replacement, or both, arthrofibrosis can cause a decrease in knee flexion and an increase in extension range of motion. Reduced shoulder girdle mobility reduces your ability to do essential activities of daily living and athletics, such as crouching, squatting, lunging, and jumping. Shah has presented an innovative solution to these problems that is both effective and inexpensive, requiring less time and less resources than traditional methods and coming with the doctor's approval.

Methodology

Data collection

The articles published or available online in PubMed, Elsevier, and Medline in English from 1982 onward were searched as part of the research approach (Wise BT, 2018). Each search returns results that include the terms physical therapy, rehabilitation, postoperative stiffness, knee arthroplasty, and physiotherapy. In order to decide which studies to include in our analysis, we read a large amount of literature. Among the most pertinent article categories were those that addressed issues like (1) knee extension lag, (2) postoperative knee stiffness, and (3) postoperative surgery (Yoshikawa Kenichi, 2018). Agreements for the provision of rehabilitative and physical therapy services; and (4) academic publications (including reviews, recommendations, comments on treatment, case reports, expansions, and original works). The effectiveness of this type of renewal, which occurs after surgery, is both immediate and long-lasting (Jette DU, 2020).

Data analysis

Thirty-four individuals were assessed subjectively and objectively for their knee limitations. Patients' ages ranged from 18 to 40, and there was minimal effort made to identify those with unique impairments. More than 60 degrees of knee flexion and nearly normal passive knee extension were used to diagnose an EL by the therapy personnel. Active and passive flexion in the prone position, as well as circumference measures at the joint line, 5 cm cranial to the patella pole, and 15 cm cranial to the patella pole, constituted the bilateral objective assessment. The EL reading was taken by the doctor lifting the patient's heel off the exam table with a clenched palm. The next instruction was for the patient to tighten his quadriceps by bringing his knee up toward the table. The examiner palpated the quadriceps tendon above the patella to detect muscular contraction (Jette DU, 2020).

He was then instructed to keep his knee straight and raise his heel above his fist. When the patient's heel was raised off the examiner's fist and the knee did not remain fully extended, it was determined that the patient had knee insufficiency. The presence or absence of EL was determined by measuring the degree to which the affected knee flexed while the leg was lifted. While goniometers were utilized to establish the study's baseline of 5" EL, the examiner relied solely on visual inspection to establish the participant's actual range of motion during trial assessments. It is important for the examiner to be at the same eye level as the patient's lower extremity in order to properly evaluate any movements in the sagittal plane (Oliva F, 2021). A total of 194 measurements of tibiofemoral, patellofemoral, and superior tibiofibular articular pain, stiffness, and crepitus were taken. We used the Maitland method for observing inertia in movement. Mobility levels ranging from "normal" to "subnormal" to "extreme" to "rigid" were all documented. Overpressure was shown to cause no pain, whereas light pressure caused only slight discomfort, and moderate pressure resulted in significant pain. Possible crepitus recordings fell into three categories: no crepitus with compression, and no crepitus with compression. Each patient was given a questionnaire consisting of 21 questions about their level of impairment, degree of joint discomfort, and general health (B. Bijish Kumar., 2016).

Result and Discussion

Extension lag (EL) measurements fell into the following categories.

Table 1
Multiple strong associations between EL and frequency

S.No.	EL	Frequency
1.	2^0	11
2.	3^0	9
3.	4^0	7
4.	6^0	5
5.	7^0	2
Total N		34

Statistically, no correlation could be found between EL and the variables we examined Nonetheless; I found the variations among the groups to be really interesting. These estimates for EL were independently arrived at by the author and a physiotherapist who saw the patient as part of the clinic's regular schedule.

Table 2
Estimations of EL that the author documented as well as estimates

S.No.	Patient number	Author's estimate	Staff's estimate
1.	2	6^0	5^0

2.	1	4^0	3^0
3.	3	4^0	2^0
4.	8	4^0	3^0
5.	12	6^0	6^0
6.	15	2^0	2^0

A large mean departure from zero was seen in measurements of extension force and flexion force taken from the affected extremity. Forces measured at the unaffected extremity's range of motion in both extension and flexion was not significantly different from zero on average. Conclusions are shown in Table.3.

Table 3
Tests comparing intact and damaged extremities measurements (N = 34)

S.No.	List of variables	Mean difference	95% confidence interval	Significant
1.	Extension force	7.21 kg	5.31 to 8.93	yes
2.	Flexion force	4.65 kg	2.15 to 6.43	yes
3.	Circumference at joint line	-2.02	-2.85 to – 1.05	yes
4.	Circumference 5 cm above patella	0.65 cm	-0.09 to 0.93	No
5.	Circumference 15 cm above patella	3.01 cm	2.03 to 4.72	yes
6.	Active flexion	-26.95 cm	-34.94 to 21.63	yes
7.	Passive flexion	-28.09 cm	-35.56 to -22.85	yes

Table 4
T-test of difference between normal and stiff extremity movements

S.No.	List of variables	Movement used to differentiate normal and stiff	N	mean		Two-tailed probability
				N= normal	S = stiff	
1.	Active flexion	Medial rotation at 10^0	25	N = 45.03 cm		00.01
		flexion	9	S = 56.34 cm		
2.	Passive flexion	Medial rotation at 10^0	25	N = 39.53 cm		00.01
		flexion	9	S = 52.85 cm		
3.	Circumference 5 cm above patella	Medial rotation at 10^0	25	N = 40.54 cm		00.05
		flexion	9	S = 37.41 cm		
4.	Circumference 15 cm above patella	Medial rotation at 10^0	25	N = 48.53 cm		00.01
		flexion	9	S = 42.23 cm		
5.	Flexion force	Medial rotation at 10^0	25	N = 13.66 cm		00.01
		flexion	9	S = 8.94 cm		
6.	Active flexion	Medial rotation at 10^0	25	N = 35.76 cm		00.01
		flexion	9	S = 56.38 cm		
7.	Passive flexion	Medial rotation at 10^0	25	N = 33.65 cm		00.01
		flexion	9	S = 56.37 cm		

Table 5
T-test of mean force difference b/w injured and unaffected extremities (N = 34)

S.No.	List of variables	Mean (kg)	Mean difference	T – value	Two-tailed probability
1.	Extension force (injured)	6.01	4.05	5.32	00.001
2.	Flexion force (injured)	10.65	-	-	-
3.	Extension force (uninjured)	13.98	1.55	1.46	00.54
4.	Flexion force (uninjured)	13.78	-	-	-

Discussion

Although this study did not find statistically significant associations between EL and any of the variables considered, it may offer some clues as to what characteristics may be most linked to EL. These findings suggest that patients with knee impairment and EL in the afflicted knee share common characteristics. It appears from these comparisons between groups that EL patients may also suffer from generalized weakness of the quadriceps, as well as stiffness and distension of the joints. Due to the lack of statistically significant links between EL and other factors, the true causes of EL cannot be determined in this study. However, most patients only showed minor EL (only 1 in 4 had 3 or more EL spots), therefore it is plausible that “The underlying cause(s) of EL were probably eased by natural causes or medical intervention before the measurements was obtained, hence factor(s) connected to EL may have gone undetected.”

Patients with high ELs (ELs 3 or higher) have supplied information suggesting a correlation between “EL and several characteristics.” Inspecting the scatter diagram reveals. Patients with lower ELs were included in the analysis, and the scattergram no longer revealed any form of connection. Future studies should focus on enrolling participants with higher ELs. The reviewed literature indicates that EL is associated with a lack of muscle strength, joint stiffness, distension, and discomfort. When it comes to the first three criteria, the results of this study are in line with what has been found elsewhere in the literature. This study did not seek to examine the attenuation of mechanical advantage or the degree to which muscles were inhibited or recruited in response to a conditioned stimulus. To pass judgment on the effect of these two variables on EL would be inappropriate.

Conclusion

In 34 cases, we found a correlation between EL at the knee and other parameters from the injured and healthy limbs. There were no discernible connections found between EL and the other metrics considered. There is some evidence that weak quadriceps contribute to the onset of EL, although it is not conclusive. There was not enough information to make an alternate variable forecast of EL. Correlations did not demonstrate a cause-and-effect link; hence, doctors are unsure of how to care for their EL patients. Joint pain, joint stiffness, joint distension, and muscular weakness have all been connected to EL. Choosing which of these need the greatest attention requires taking into account both the patient's perspective and the medical evidence. Exercises for the weak should be done at the very edge of their functional range, either against gravity or in a gravity-reduced position. The patellofemoral, superior tibiofibular, and tibiofemoral joints could benefit from increased natural or supplementary motion. When performing terminal extension exercises, it may be helpful to keep the stretched-out position for brief periods of time between repetitions in order to maximize the “muscle pump” and reduce joint distention. When it comes to relieving pain, mobilization may help with chemically-induced pain, while modalities are more effective against mechanical trauma. Whether or whether a treatment is successful can be gauged by recording the patient's subjective and objective reactions over time.

Future scopes

There is some doubt about the efficacy of different treatment options because most research can't agree on standard procedures for physiotherapy and rehabilitation. To discover the most effective interventions, RCTs must be carefully constructed. The statistical power of the study permits us to conclude that it belongs in the category of therapeutic interventions. It's not debatable that more study is needed in these fields. Therefore, it is crucial to evaluate the short- and long-term benefits of different types of physical activity.

References

1. Alnahdi AH, Zeni JA, Snyder-Mackler L., 2011. Gait after unilateral total knee arthroplasty: frontal plane analysis. J Orthop Res. 647–652. http://dx.doi.org/10.1002/jor.21323.
2. Ares O, Lozano LM, Medrano-Nájera C, 2014. New modified Achilles tendon allograft for treatment of chronic patellar tendon ruptures following total knee arthroplasty. Arch Orthop Trauma Surg. 2014; 134:713–7. https:// doi. org/ 10. 1007/ s00402- 014- 1951-6.
3. Bhaskaran Bijish Kumar., 2016. Effects of physiological quadriceps lag among male young healthy students. International Journal of Physical Education, Sports and Health.
4. Boettner F, Bou MJ. 2015., Achilles tendon allograft for augmentation of the Hanssen patellar bone grafting. Knee Surg Sports Traumatol Arthrosc. 23:1035–8. https:// doi. org/ 10. 1007/ s00167- 014- 2845-4.
5. Bonnin M, Lustig S, Huten D., 2016. Extensor tendon ruptures after total knee arthroplasty. Orthop Traumatol Surg Res. 2016; 102(1 Suppl):S21-31. https:// doi. org/ 10. 1016/j. otsr. 2015. 06. 025.
6. Busfield BT, Ries MD., 2006., Whole patellar allograft for total knee arthroplasty after previous patellectomy. Clin Orthop Relat Res. 450:145–9. https:// doi. org/ 10. 1097/ 01. blo. 00002 23980. 44455. 21.
7. Cheuy VA, Foran JRH, Paxton RJ, 2017. Arthrofibrosis associated with total knee arthroplasty. J Arthroplasty. https:// doi. org/ 10.1016/j. arth. 2017. 02. 005. 32:2604–11.
8. Coraci D, Paoloni M, Coco S, 2016. Letter to the editor on no differences identified in transverse plane biomechanics between medial pivot and rotating platform total knee implant designs. J Arthroplasty. 16:30038–30039. http://dx.doi.org/10.1016/j. Arth.2016.03.056 Apr 12. pii: S0883-5403.

9. Ellanti P, Moriarity A, Wainberg N, Ni Fhoghlu C, McCarthy T. 2015. Association between patella spurs and quadriceps tendon ruptures. MLTJ. https:// doi.org/ 10. 11138/ mltj/2. 088.
10. Jette DU, Hunter SJ, Burkett L, Langham B, Logerstedt DS, Piuzzi NS, 2020. Physical therapist management of total knee arthroplasty. Phys Ther; 100:1-29.
11. Kumar R, Kaushal K, Kaur S. 2020. Role of physiotherapy in post-operative knee stiffness: A literature review. Adesh Univ J Med Sci Res, 2(1):31-5.
12. Liberati A, Altman DG, Tetzlaff J, 2009. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. J Clin Epidemiol. 2009; 62:e1-34. https://doi.org/10.1016/j.jclin epi. 06. 006.
13. Lim CT, Amanatullah DF, Huddleston, 2017. Reconstruction of disrupted extensor mechanism after total knee arthroplasty. J Arthroplasty. 32:3134–40. https://doi.org/10.1016/j. arth. 05. 005.
14. Maffulli N, Spiezia F, La Verde L, 2017. The management of extensor mechanism disruption after total knee arthroplasty: a systematic review. Sports Med Arthrosc. 25:41–50. https://doi. org/ 10. 1097/ JSA. 0000000000 000139.
15. Makino Koji. 2016. Automatic rehabilitation of the Extension Lag using the developed knee assistive instrument. 2017 IEEE International Conference on Information and Automation (ICIA).
16. Novoa, R. B. (2021). State of the art and future applications of digital health in Chile. International Journal of Health & Medical Sciences, 4(3), 355-361. https
17. Oliva F, Marsilio E, Migliorini F, Maffulli N. J Orthop Surg Res., 2021. Complex ruptures of the quadriceps tendon: a systematic review of surgical procedures and outcomes. 16(1):547. doi: https:// doi. org/ 10. 1186/s13018- 021- 02696-9.
18. Papagiannis GI, Roumpelakis IM, Triantafyllou AI, 2016. Response to letter to the editor on no differences identified in transverse plane biomechanics between medial pivot and rotating platform total knee implant designs. J Arthroplasty. http://dx.doi.org/10.1016/j.arth.2016.03.055. 2373.
19. Papalia R, Vasta S, D'Adamio S, 2015. Complications involving the extensor mechanism after total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc. https://doi.org/10.1007/s00167- 014- 3189-9.
20. Patra Anirban, Kumar Niraj, Chauhan Archana, 2018. Effect of SLR and Isometric Exercise on Quadriceps Lag of Normal Health Individual. Physiotherapy and Occupational Therapy Journal; Volume 11.
21. Rajcoomar, Riona. 2017. Functional outcomes post total knee arthroplasty following electrical muscle stimulation on the quadriceps muscle. Chris Hani Baragwanath Academic Hospital.
22. Serino J, Mohamadi A, Orman S, 2017. Comparison of adverse events and postoperative mobilization following knee extensor mechanism rupture repair: a systematic review and network meta-analysis. Injury. 48:2793–9. https://doi.org/10.1016/j.injury.
23. Widana, I.K., Sumetri, N.W., Sutapa, I.K., Suryasa, W. (2021). Anthropometric measures for better cardiovascular and musculoskeletal health. *Computer Applications in Engineering Education*, *29*(3), 550–561. https://doi.org/10.1002/cae.22202

24. Wijayanti, N. (2021). Factors related to behavior the community in disposing of garbage. International Journal of Health & Medical Sciences, 4(1), 74-79. https://doi.org/10.31295/ijhms.v4n1.1226
25. Wise BT, Erens G, Pour AE, 2018. Long-term results of extensor mechanism reconstruction using Achilles tendon allograft after total knee arthroplasty. Int Orthop. 42:2367–73. https:// doi. org/ 10. 1007/s00264- 018- 3848-4.
26. Wood TJ, Leighton J, Backstein DJ, 2019. Synthetic graft compared with allograft reconstruction for extensor mechanism disruption in total knee arthroplasty: A Multicenter Cohort Study. J Am Acad Orthop Surg. 27:451–7. https://doi.org/10.5435/JAAOS-D-18-00393.
27. Xing W, Sun L, Sun L, Liu C, Kong Z, Cui J, 2018. Comparison of minimally invasive arthrolysis vs. Conventional arthrolysis for post-traumatic knee stiffness. J Orthop Sci; 23:112-6.
28. YoshikawaKenichi , Mutsuzak Hirotaka; 2018. Training with Hybrid Assistive Limb for walking function after total knee Arthroplasty. Journal of Orthopaedic Surgery and Research.