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STRESS MARKERS PADA LUMBAR VERTEBRAE

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Abstrak

Perajin sarung tenun di Desa Wedani dalam melakukan aktivitas pekerjaannya membuat kain sarung menggunakan alat tenun bukan mesin. Pekerjaan dimulai dari jam 07.00 hingga 16.30 selama 6 hari bekerja dalam seminggu dengan menghasilkan kain sarung berjumlah 1 sampai 4 kain per harinya. Kegiatan perajin ketika menggerakkan alat tenun memiliki beban tumpuan yang terletak pada lumbar vertebrae, karena saat menenun perajin dalam posisi duduk 90°. Penelitian ini bertujuan untuk mendeskripsikan bentuk stress markers dan letaknya yang terkait dengan lama masa kerja, intensitas dalam beraktivitas, serta otot gerak anggota tubuh dari ekstremitas atas dan ekstremitas bawah yang berpengaruh paling besar terhadap munculnya osteopit pada lumbar vertebrae. Penelitian yang dilakukan menggunakan teknik pengumpulan data berupa hasil rontgen serta didukung dengan studi pustaka berkaitan dengan sistem otot pada lumbar vertebrae yang mempengaruhi sistem gerak. Hasil analisis foto rontgen menunjukkan terdapat stress markers berupa osteopit sebanyak 42,8% pada lumbar vertebrae perajin sarung tenun dengan letak osteopit yang sama. Stress markers muncul berupa osteopit pada lumbar vertebrae perajin sarung tenun sesuai dengan tingginya faktor usia yaitu 43-47 tahun, lamanya masa kerja yaitu 30-35 tahun, intensitas dalam bekerja, dan beban yang diberikan anggota tubuh yaitu ekstremitas atas dan ekstremitas bawah pada lumbar vertebrae sebagai tumpuan ketika menggerakkan alat tenun. Berdasarkan dari hasil foto rontgen pada lumbar vertebrae perajin sarung tenun di Desa Wedani, menunjukkan bahwa dari 7 sampel terdapat 3 sampel yang mengalami stress markers berupa osteopit pada lumbar vertebrae dan 4 sampel memiliki kondisi normal.

***Kata Kunci**: Stress markers, lumbar vertebrae, perajin sarung tenun Desa Wedani.*

Abstract

Woven sarong craftsmen in Wedani Village in carrying out their work activities make sarongs using non-machine looms. Work starts from 07.00 to 16.30 for 6 working days a week by producing 1 to 4 sarongs per day. The craftsman's activities when moving the loom have a support load that lies on the lumbar vertebrae, because when weaving the craftsman is in a 90° sitting position. This study aims to describe the shape of stress markers and their location related to length of work, intensity of activity, and limb movement muscles of the upper and lower extremities which have the greatest influence on the appearance of osteophytes in the lumbar vertebrae. The research was conducted using data collection techniques in the form of X-ray results and supported by literature studies related to the muscular system in the lumbar vertebrae which affect the movement system. The results of X-ray analysis showed that there were 42.8% stress markers in the form of osteophytes in the lumbar vertebrae of woven sarong craftsmen with the same location of osteophytes. Stress markers appear in the form of osteophytes on the lumbar vertebrae of woven sarong craftsmen according to the height of the age factor, namely 43-47 years, length of working period, namely 30-35 years, intensity of work, and the burden on the limbs, namely the upper extremities and lower extremities on the lumbar vertebrae as a support when moving the loom. Based on the X-ray results of the lumbar vertebrae of the woven sarong craftsmen in Wedani Village, it shows that out of 7 samples, 3 samples experienced stress markers in the form of osteophytes on the lumbar vertebrae and 4 samples had normal conditions.

***Keywords**: Stress markers, lumbar vertebrae, Wedani Village woven sarong craftsmen.*

1. INTRODUCTION

When doing a job with the intensity of a long time it can cause marks on the bones called stress markers. Activity patterns involving muscles and joints are indicators that can cause stress markers on bones. Jobs have different loads so that the marks that appear on the bones due to work activities are known for a long time, the possibility of the appearance of osteophytes and stress markers on the bones depends on the age of the subject who is getting more mature and the number of activities that respond to and

affect the muscles or ligaments (Lieverse et al., 2009).

Signs of stress caused by work have four types, namely: 1) modification to areas of insertion involving pressure on soft tissues such as muscles and joints, 2) osteophytosis is a condition where bone grows in the shape of a small ridge located in a normal area that smooth and flat, 3) certain signs (discrete markers) originate from activities that affect the shape of the bones, and 4) stress that causes fractures is the result of repeated activities and creates an impact, namely stress on the bones (Byers, 2010).

Indonesia is a country that is famous for its traditional culture, with a variety of tribes and cultures, so it is not surprising that Indonesia can also produce a variety of quality handicrafts in several regions. One of them is in the textile sector, namely woven sarongs. The manufacture of woven sarongs in Wedani Village uses Non-Machine Weaving Tools (ATBM). Non-Machine Weaving Tools (ATBM) are a form of equipment used to make woven fabrics and are driven manually by human power. The development of this tool comes from the gedogan loom, the difference is that the Non-Machine Weaving Tool (ATBM) is made like a loom machine frame which makes it easier to use.

The vertebrae in this condition act as a fulcrum when the two limbs, namely the upper and lower extremities, move the Non-Machine Weaving Tool (ATBM). The attitude shown by the vertebrae when in a sitting position, assumptions arise regarding whether there is an influence from the motion of the two limbs on the passive vertebrae. Vertebral balance, which is affected by the curves in the three areas of the vertebral column, produces a person's posture. A good poster requires good function of a number of bones such as the vertebrae, pelvis and lower extremities (Vitriana, 2001). Work as a woven sarong craftsman who requires the craftsman to always sit while doing weaving work and only be passive. If this activity is carried out continuously and with high intensity in activities related to the vertebrae, it is possible for signs of stress markers to appear on the bones.

3. RESEARCH METHOD

This research was conducted to determine stress markers based on the bone condition of the sarong woven craftsmen, which were identified through the age, length of work, and activity intensity of the woven sarong craftsmen. In conducting this research, the thing that was done was to directly observe the activities of woven sarong craftsmen. Activities in the work of weaving sarongs in a sitting position and carried out every day, allow for the appearance of marks on the bones. The type of research used is descriptive quantitative by identifying forms of stress markers between individuals through X-ray results.

4. RESULTS AND DISCUSSION

Based on table 1, it shows that the stress markers that appear in each research subject are different. Three of the seven study subjects had osteophytes on their lumbar vertebrae, while four of the seven study subjects did not find any stress markers on the lumbar vertebrae. Several factors influence the appearance of differences in stress markers on the lumbar vertebrae caused by long periods of work.

Of the several subjects who showed stress markers in the form of osteophytes, there were also subjects who had normal bone conditions and did not display stress markers, this was caused by long hours of work. The activity of the woven sarong

craftsmen is using the upper extremity limbs to move the cross beam/chest beam, and the lower extremity limbs to move the stamping on the loom. The lumbar vertebrae here play a role as a support for the body which is related to the sitting position, because the woven sarong craftsmen when doing weaving activities are in a 90˚ sitting position. So that the lumbar vertebrae indirectly receive pressure when the two limbs move the loom.

Table 1. Frequency of the emergence of osteophyte stress markers in the lumbar vertebrae of study subjects

subject	Number of Sarongs (Per Day)	Years of service (per year)	Long working frequency		Place Stress Markers
			Per day	Per week	
SA	2 scabbards	30	9 hours	6 days	L4
K	1 sheath	35	9 hours	6 days	L3-L4
AM	4 scabbards	33	9 hours	6 days	L3-L4
AN	2 scabbards	20	9 hours	6 days	Normal
E	1 sheath	22	9 hours	6 days	Normal
N	1 sheath	26	9 hours	6 days	Normal
KR	1 sheath	20	9 hours	6 days	Normal

The factors that influence whether or not stress markers appear are the length of time worked and the frequency with which the woven sarong craftsmen produce sarongs per day, because even though woven sarong craftsmen have the same working hours, each individual produces a different amount of sarong and the length of time. different work. So the presence or absence of stress markers on the lumbar vertebrae of sarong woven craftsmen is influenced by the length of time they work, the intensity of their activities, and the movements of the upper and lower extremities.

*Stress markers*which appeared on the lumbar vertebrae in the form of osteophytes were found in subjects SA, K, and AM. The emergence of osteophytes is caused when the upper extremities move the crossbar / chest beam forward and backward for a long time, the muscles that move are the extensor pollicis longus muscle found in the thumb, the extensor digitorum muscle in the index finger to the little finger. The muscles attached from the wrist to the upper arm are the flexor carpi radialis, palmaris longus, flexor digitorum superficialis, flexor carpi ulnaris, extensor carpi ulnaris, extensor indicis, and muscles that help movement when the elbow bends when pulling wood, namely the biceps brachii and triceps muscles. brachii.

The lower extremities when moving the loom up and down, the muscles that move are the extensor digitorum longus and

extensor hallucis longus muscles assisted by the sartorius muscle, tensor faciae latae muscle, rectus femoris muscle, semitendinosus muscle, vastus lateralis muscle, vastus medialis muscle, adductor magnus, gracilis muscle, biceps femoris muscle, gastrocnemius muscle, and tibialis anterior muscle. These muscles affect the trapezius muscle which originates at the vertebrae section C1-C6 and the spinous processes of the vertebrae C7-T3 and the intervening supraspinous ligament, the deltoids muscle which originates at the clavicle and scapula, the infraspinatus muscle which originates at the infraspinatus fossa of the scapula and ends at the tubercle of the humerus, the serratus anterior muscle which originates on the outer surfaces of the upper eight ribs,

The erector spine extends on both sides of the vertebral column, between the base of the skull superiorly and the pelvis inferiorly, the gluteus medius muscle its attachment area extends between the anterior and posterior gluteal lines, taking an anteroinferior course to the proximal femur, the gluteus maximus muscle originating on the lateroposterior surface of the sacrum and coccyx, gluteal surface of ilium (behind posterior gluteal line), thoracolumbar fascia, and sacrotuberous ligaments(Oatis, 2009). Movement in the lumbar vertebrae is also influenced by the psoas muscle which is located at the back of the abdominal cavity, although this muscle is basically a hip joint muscle, its action on the lower vertebrae and pelvis is quite large. Because the psoas muscle at the proximal end attaches the sides of the body to the front and lower limit of the transveral processes of all lumbar vertebrae, and as a lumbar propulsion in collaboration with the erector spine muscles, the gluteus medius muscle located on the illium, and the gluteus maximus muscle (Hamilton et al., 2003).

The parts of the body, namely the upper and lower extremities, have an influence on the emergence of osteophytes in the lumbar vertebrae, because these two parts of the body move the loom and the lumbar vertebrae here are passive, where they only receive pressure from these two parts of the body. The upper extremity up to the shoulder moves the cross beam / chest beam which affects the infraspinatus muscle, serratus anterior muscle, and teres major muscle while the lower extremity up to the hip when moving the stomp of the loom affects the gluteus medius and gluteus maximus muscles. Ends in an area that receives pressure from two parts of the body, namely the lumbar vertebrae which are attached to the psoas muscles and the erector spine muscles.

Furthermore, in subjects who have stress markers in the form of osteophytes, there is a disorder, namely lumbar spondylosis. Lumbar spondylosis is an excess change of bone due to increased intervertebral disc degeneration followed by changes in bone and soft tissue in the vertebrae. Increasing age also affects degenerative changes in the vertebrae. Repeated loading can also cause structural injury and development of pain (Devlin, 2011).

DISCUSSION

Stress markers is a marker on the bone caused by activities that involve the performance of muscles and joints continuously so that it leaves marks on the bones (Byers, 2010). Stress markers that appear on human bones related to work have been studied by Turner Thackrah (1832) on weavers. Turner found a deformation of the weaver's pelvic bones, and the presence of features of scoliosis in the weaver's vertebrae. This, according to Turner, is the result of the craftsmen's habits when

weaving, namely sitting for long periods of time (Iscan, MY and Kennedy, 1989).

Based on the data obtained, three out of seven woven sarong craftsmen have osteophytes in their lumbar vertebrae. Four out of seven people have a normal condition and there are no signs of stress on their bones. The appearance of osteophytes in the lumbar vertebrae of sarong woven craftsmen is in line with Wolff's (1902) statement, namely that bones respond to stress received. This response occurs in line with the increase and decrease in the mass of the bone itself, so that it can withstand pressure from other limbs (Kennedy, 1989).

The problem of back pain in workers begins to appear during adulthood with a peak prevalence in the age group around 25 to 60 years (Linton, 2005). Several types of work tools and facilities that are uncomfortable sometimes raise health problems for workers, if used with frequent intensity and for a long period of time it does not rule out the possibility of having a negative effect on health which triggers work-related disorders (Agustin, 2012). When the posture of the back is not in an upright position at work and the sitting position is not good, there is a risk of causing disease in the form of musculoskeletal disorders which cause stiffness and pain in the vertebrae. If the attitude of sitting for a long time in a chair that lacks ergonomics will cause health problems for workers (Punnett, 2005).

Complaints that are felt in the vertebrae area or musculoskeletal complaints are complaints in the skeletal muscles that are felt with different intensities, from mild pain to very painful pain (Tarwaka et al., 2004). Pain sensory nerve influences produce reactions of discomfort and distress. The most intense pain appears, usually in the form of acute pain, which can sometimes disappear. The cause of back pain cannot always be determined, but the place where the pain first appears can be used to indicate the cause of the pain. Back pain can also be caused by the displacement of one of the bearings between the vertebrae or pressure on the pelvic nerves (Dagenais et al., 2008). The attitude of the body when working is a picture when moving related to the position of the body, head and limbs, namely the hands and feet both in the relationship between the body parts and the location of the center of gravity.

Lumbar spondylosis is a cause of backbone pain disorders, due to the narrowing of the distance between the vertebrae resulting in osteophytes, narrowing of the spinal canal and intervertebalis foramen and irritation of the posterior joints. Lumbar spondylosis often forms due to aging or degeneration. As age increases, degenerative changes in the vertebrae can occur, consisting of dehydration and herniated nucleus pulposus and protrusion in all directions of the annulus fibrosus. Ostepit or spurs are formed because the annulus undergoes hypertrophic changes at the edges of the vertebral bodies (Kusumaningrum, 2014).

Table 2. Stress markers on woven sarong craftsmen

Stress Markers	Number of Individuals	Percentage
Osteophyte	3	42.8%
Normal	4	57.2%
Amount	7	100%

Table 2 shows that not all research subjects, namely woven sarong craftsmen, have stress markers on their lumbar vertebrae. Based on the analysis of the data obtained, 42.8% of the study subjects had stress markers in the form of osteophytes on the lumbar vertebrae, and 57.2% of the study subjects experienced normal conditions and had no signs of stress markers. Basically the activities carried out by the research subjects were the same, starting from how to weave, the length of time they worked in a day from 07.00 am to 16.30 pm, as well as the sitting position. So the emergence of different stress markers for each individual can be caused by differences in age, length of work, and the number of sarongs produced by each craftsman.

Table 3. The relationship between length of work and the frequency of the amount of cloth produced on the emergence of osteophytes in woven sarong craftsmen per day

Working period 11-20 years		*Stress markers*		Amount
		Osteophyte	Normal	
The amount of fabric produced	1-3	-	2	2
	4-6	-	-	0
Working period 21-30 years				
The amount of fabric produced	1-3	1	2	3
	4-6	-	-	0
Working period 31-40 years				
The amount of fabric produced	1-3	1	-	1
	4-6	1	-	1
Amount		3	4	7

The table shows that the length of working time and the frequency of cloth produced by woven sarong craftsmen can cause stress markers on the lumbar vertebrae of woven sarong craftsmen. Based on the table, it can be seen that woven sarong craftsmen who have a working life of 21-30 years with a frequency of cloth produced per day, namely 1-3 sarongs, have one subject who has osteophytes. Sarong woven craftsmen who have worked for 31-40 years with a frequency of cloth produced, namely 1-3 sarongs, one subject has osteophytes, and 4-6 sarongs, one subject has osteophytes. Based on these data, it can be said that osteophytes began to appear in artisans who had worked for more than 21 years, although some were in normal condition.

Based on table 4.2, it can be analyzed that the emergence of osteophytes in the lumbar vertebrae of woven sarong craftsmen is caused mostly by the length of time they work and the intensity of making sarongs in a day. The woven sarong craftsmen form a sitting position when the body performs weaving activities, the body's fulcrum is located on the vertebrae when the force

comes from the upper and lower extremities. When this activity takes place the upper extremity pushes the crossbar / chest beam towards the front and back and the lower extremity moves the loom treads up and down. This is done for 9 hours per day when the woven sarong craftsmen make the sarongs.

In the upper extremities, when moving the crossbar / chest beam towards the front and back, it is moved by muscles, starting from the fingers when gripping the crossbar / chest beam, there is the extensor pollicis longus muscle which acts as a thumb mover and extensor digitorum as a pointer finger mover. up to the little finger. The wrist, elbow, and shoulder are moved by the palmaris longus muscle, extensor indicis (tendo), extensor carpi ulnaris, flexor carpi ulnaris, flexor digitorum superficialis (tendines), flexor carpi radialis, triceps brachii and biceps brachii muscles. , deltoids, and trapezius muscles. The activity of the muscles attached to the upper extremities to the shoulders terminates and puts pressure on the cervical and thoracic vertebrae.

The lower extremities contain the gluteus medius and gluteus maximus muscles which put pressure on the psoas muscles and erector spine muscles, in coordination with the lower extremity limbs which also put pressure on the lumbar vertebrae when these limbs move the loom stamping up and down, this activity It is affected by muscles located from the hamstring to the ankle, namely the sartorius muscle in the upper thigh, tensor fasciae latae, rectus femoris, semitendinosus, vastus lateralis, vastus medialis, adductor magnus, gracilis, biceps femoris, gastrocnemius, and tibialis anterior.On the ankle, which gives the main pressure to the upper part of the body, it is influenced by the extensor digitorum longus and extensor halluces longus muscles to move the stamping on the loom with the sole of the foot attached to the stamping (Netters, 2014).

Wolff (1902) suggested that bones can adjust to the pressure received, namely by increasing bone mass (Kennedy, 1989). Osteopits in the lumbar vertebrae of sarong woven craftsmen also appear as a result of the pressure received by the spine repeatedly and over a long period of time. This also applies to the woven sarong craftsman when moving the loom, even though the back position is in a passive state but it causes osteophytes in the lumbar vertebrae, the magnitude of the effect that is produced is in addition to the length of time the woven sarong craftsmen work in the field of work, also the intensity of movement in the limbs that affects the lumbar vertebrae as a fulcrum when sitting.

It has been explained previously that when the craftsman moves the loom, the limbs that affect are the limbs of the upper and lower extremities, as well as which muscles affect the movement and which end in the bones. This explanation answers the reason why osteophytes attack the lumbar vertebrae, while the lumbar vertebrae are in a passive position. Even though the two limbs move the loom, the one that has the greatest influence on the emergence of osteophytes in the lumbar vertebrae is the limbs of the lower extremities.

The muscles in the upper extremities tend to influence movement in the upper body to the abdomen so that the influence on the lumbar vertebrae when the craftsman moves the crossbar / chest beam is not so great, while for the lower extremities it has a greater effect on the lumbar vertebrae, where the muscles Pelvic muscles when the craftsman sits put additional pressure on the lumbar vertebrae apart from when the craftsman moves the loom. Furthermore, when the woven sheath maker moves the tread on the loom, the lower extremity tends

to be active and there is a slight pause compared to when the upper extremity moves the crossbar.

The activities that have been carried out began to appear disturbances which were preceded by pain in the back and became the initial complaint of the woven sarong craftsmen when the researchers conducted direct interviews with the craftsmen. Back pain, which is also known as lumbar spondylosis, which in the previous discussion has been explained to be related to the narrowing of the distance between the vertebrae, is an initial disturbance for the artisan by looking at the factors previously stated regarding movement and the length of time of work, being a symptom towards the emergence of osteophytes as the craftsman continues to work. with a long period of time.

Attitudes that affect back pain are sitting habits, working in a sitting position for a long time, and sitting in chairs that are not ergonomic for the body. This is because the spine along with the tendons and muscles are forced to support the back to remain upright for long periods of time, this causes fatigue in the back muscle tissue, especially the lumbar region. The work resulted in a herniated nucleus pulposus due to pressure on the vertebral nerve cushions (Ghannam, 2017). This consequence is the result when the back receives a static load from the limbs of the upper and lower extremities when moving the loom for a long time.

The basic reason is why the lumbar vertebrae are the focus of researchers and not other vertebrae such as cervical and thoracic. Starting from the results of interviews with woven sarong craftsmen, the majority of whom complained of pain in the lower back, namely between the lumbar vertebrae and the pelvis. This information was then supported by researchers observing the movements of the craftsmen when moving the loom where two limbs, namely the upper extremity and lower extremity affect the vertebrae, and saw which part of the body received the greatest influence from the movement of the two limbs by looking at several aspects as described above. previously.

Craftsmen do their work in a sitting position, and also with non-ergonomic seating conditions, researchers relate the matter of which bone is more dominant to bring up stress markers when craftsmen sit for long periods of time. It can be seen that the lumbar plays a role in supporting the body compared to the other two bones, because the lumbar in the previous explanation has said that the muscles in the pelvis are the link between the lower extremities and the lumbar vertebrae. The muscles that are interconnected in the lumbar vertebrae tend to get pressure from the pelvis when sitting and also get pressure when the feet move the loom, so this explanation strengthens the reason why the lumbar vertebrae are the object for X-rays in this study.

5. CONCLUSIONS

Based on the X-ray results of the lumbar vertebrae of the woven sarong craftsmen in Wedani Village, it shows that out of the 7 research samples, 3 samples experienced stress markers in the form of osteophytes on the lumbar vertebrae and 4 samples had normal bone conditions. The location of the osteophyte points owned by woven sarong craftsmen, namely 1 artisan has osteophytes in the L4 bone section and 2 woven sarong craftsmen have osteophytes in the L3-L4 sections.

Stress markers in the form of osteophytes in the lumbar vertebrae of sarong loom craftsmen, caused by the static load that the spine receives when the upper extremity moves the crossbar and the lower

extremity moves the stamping on the loom. These two loads exert pressure through the muscles originating in the spine, in addition to the effects of static loads. Osteopit appears influenced by the length of time the craftsman has worked as a woven sarong maker, which is more than 20 years, as well as the intensity in his activities, which is 6 days a week with 9 hours of work per day.

The emergence of pain in the form of spondylosis in the lumbar vertebrae is caused by movement activity when moving the loom, and finally the influence of the long time the craftsman has worked as a woven sarong maker so that the pain felt turns into a disturbance in the form of osteophytes, which is in accordance with the explanation related to the frequency of emergence of stress markers in the form of osteophytes through The duration of work, namely the longer the woven sarong craftsmen work, affects the emergence of stress markers in the form of osteophytes on the lumbar vertebrae.

BIBLIOGRAPHY

Agustin, C. P. M. (2012). Work period, work attitude, and occurrence of carpal syndrome in batik batters. *Journal of Public Health, 7*(2), 170–176.

Byers, S. N. (2010). *Introduction to forensic anthropology*. Routledge.

Dagenais, S., Caro, J., & Haldeman, S. (2008). A systematic review of low back pain cost of illness studies in the United States and internationally. *The Spine Journal, 8*(1), 8–20. https://doi.org/10.1016/j.spinee.2007.10.005

Devlin, V. J. (2011). *Spine secrets plus* (2nd ed.). Elsevier Health Sciences.

Ghannam, M., et al. (2017). Surgical anatomy, radiological features, and molecular biology of the lumbar intervertebral discs. *Clinical Anatomy, 30*(2), 251–266. https://doi.org/10.1002/ca.22822

Hamilton, N., Weimar, W., & Luttgens, K. (2003). *Kinesiology: Scientific basis of human motion* (Issue 1). https://doi.org/10.16309/j.cnki.issn.1007-1776.2003.03.004

İşcan, M. Y., & Kennedy, K. A. R. (1989). *Reconstruction of life from the skeleton*. Alan L. Riss Inc.

Kennedy, K. A. R. (1989). Markers of occupational stress: Conspectus and prognosis of research.

Kusumaningrum, P. W. (2014). Physiotherapy management of low back pain due to lumbar spondylosis and scoliosis at RSUD Dr. Moewardi Surakarta. Muhammadiyah Surakarta University.

Lieverse, A. R., Bazaliiskii, V. I., Goriunova, O. I., & Weber, A. W. (2009). Upper limb musculoskeletal stress markers among Middle Holocene foragers of Siberia's Cis-Baikal region. *American Journal of Physical Anthropology, 140*(4), 458–472. https://doi.org/10.1002/ajpa.20964

Linton, S. J. (2005). Do psychological factors increase the risk for back pain in the general population? A cross-sectional and prospective analysis. *European Journal of Pain, 9*(4), 355–361. https://doi.org/10.1016/j.ejpain.2004.08.002

Netters, F. H. (2014). *Atlas of human anatomy* (6th ed.). Elsevier Singapore Pte Ltd.

Oatis, C. A. (2009). *Kinesiology: The mechanics and pathomechanics of human movement* (2nd ed.). Lippincott Williams & Wilkins.

Punnett, L. (2005). Estimating the global burden of low back pain attributable to combined occupational exposures. *American Journal of Industrial*

Medicine, 48(6), 459–469. https://doi.org/10.1002/ajim.20232

Tarwaka, Solichul, & Sudjajeng, L. (2004). *Ergonomics for safety, health, and productivity*.

Vitriana. (2001). Anatomical and biomechanical aspects of the lumbosacral bone in relation to low back pain. SMF Medical Rehabilitation FK UNPAD/RSUP Dr. Hasan Sadikin FK UI/RSUPN Dr. Ciptomangunkusumo.