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Journal Homepage: http://ejournal.upi.edu/index.php/JPKI

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The Assessment of Muscle Strength in Fracture Patients with Manual Muscle Testing: Narrative Literature Review

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A B S T R A C T

Decreased muscle strength in fracture patients can be caused by postoperative immobilization, thus requiring early immobilization to accelerate the fracture healing process. The principle of early immobilization is the same as the assessment of muscle strength, namely flexion, extension, and rotation to determine muscle strength in fracture patients. To determine the decrease in muscle strength with the Manual Muscle Testing (MMT) method in fractured and non-fractured patients. Narrative literature review was chosen in this research design. Literature search through seven databases with keywords using boolean operators and found 6533 articles. The selection process is based on several criteria: the publication year 2015-2020, full-text access, National (SINTA) / International (Scimagojr) indexed articles, in English or Indonesian, so that 11 articles were reviewed in this study. MMT is a reliable measurement tool, does not require additional tools to assess muscle strength and is universal (can assess muscle strength in fractures and non-fractures). MMT examination needs to be performed on fracture patients to determine muscle strength to accelerate the muscle recovery process.

ARTICLE INFO

Article History:

Received: *July 27, 2020*
Revised: *November 15, 2020*
Accepted: *March 21, 2021*
First Available Online: *June 30, 2021*
Published: *June 30, 2021*

Keywords:
fracture, manual muscle testing, muscle strength assessment

1. INTRODUCTION

In general, muscle strength in fracture patients has decreased (Gao et al., 2015). One can be caused after surgery. Some problems arose based on nursing diagnoses in fractured patients, such as physical barriers to physical mobility in Wilkinson (Jitowiyono dan Kristiyanasari, 2010). The factors related to physical mobility constraints, namely decreased muscle strength in patients after fracture surgery (NANDA, 2018). Fracture is a condition of reduced bone continuity when a load is placed on the bone that exceeds its biological capacity (Swearingen, 2016).

Muscle strength in patients with elbow fracture in Bulgaria experienced a decrease in muscle strength; it can be seen from the elbow extension movement with a score of 3 as much as 56.7%, which should be a normal score for muscle strength of 5 (Belomazheva-dimitova, 2020). Fracture patients who experienced a decrease in muscle strength were 37% out of 234 fracture patients in Sichuan, China, and 23.5% of fracture patients from a total of 487 patients in Wenchuan, China (Gao et al., 2015) (Zhang, 2011). The decrease in muscle strength in fracture patients at the Physiotherapy Clinic of Kimia Farma Pharmacy, Pekalongan, can be seen from the value of muscle strength in physiotherapy patients, namely muscle strength 4, which is not normal muscle strength (Kurniasari, 2010).

After surgery, the patient will usually be bandaged to protect the bone repair structure for a while to reduce movement, which can result in obstacles to physical mobility and cause muscle disorders (Macdermid, 2012; Jitowiyono and Kristiyanasari, 2010). Therefore it is necessary to measure muscle strength in postoperative fracture patients so that therapy can be determined to accelerate the healing process. Several techniques for measuring muscle strength, namely Manual Muscle Testing (MMT), Repetition Maximum (RM), and Field Testing. However, measuring instruments that are considered reliable, often used, and do not require other tools is MMT, so that the purpose of this study was to determine the assessment of muscle strength in fracture patients using the Manual Muscle Testing (MMT) method and to determine the value of muscle strength in fracture patients.

2. METHOD

Research Design

This research design uses the Narrative Literature Review method, a comprehensive, critical, and objective analysis (Don, Cnor, & Faan, 2016).

Research Strategy

The search for literature in this narrative literature review uses seven databases, namely Pubmed, Science Direct, Ebscohost, Nature, Wiley Online Library, Springerlink, and Google Scholar. The article search uses the keywords "fracture," "muscle strength," and "manual muscle testing," which is included in the boolean operator strategy (AND, OR, and NOT) to become "fracture" OR "muscle strength" OR "manual muscle testing."

The results of literature search through seven databases and using keywords using the Boolean operator, the researcher found 6533 articles that match these keywords consisting of 748

DOI: http://dx.doi.org/10.17509/jpki.v7i1.26804
e-ISSN 2477-3743 | p-ISSN 2541-0024

articles (Google Scholar), 167 articles (Science Direct), 1584 articles (Wiley Online Library), 1976 articles (Pubmed), 1584 articles (Springerlink), 471 articles (Ebscohost), and 3 articles (Nature).

Articles Selection

From the total number of articles, there were 6533, which were then selected based on inclusion criteria, 1) publication year 2015-2020; 2) can be accessed in full text; 3) national (SINTA) or international (Scimagojr) indexed articles; 4) using English or Indonesian excluded so that there were 11 articles used for writing this study. These criteria are included by considering the journals used following the use of the narrative literature review method which uses primary research with the published the year 2015-2020 to adjust to the renewal of health science developments every year and considering the index of the articles used to ensure the quality of the articles. While the exclusion criteria used 1) journals that discuss fractures other than upper and lower extremities; 2) proceedings; and 3) journals other than the MMT method.

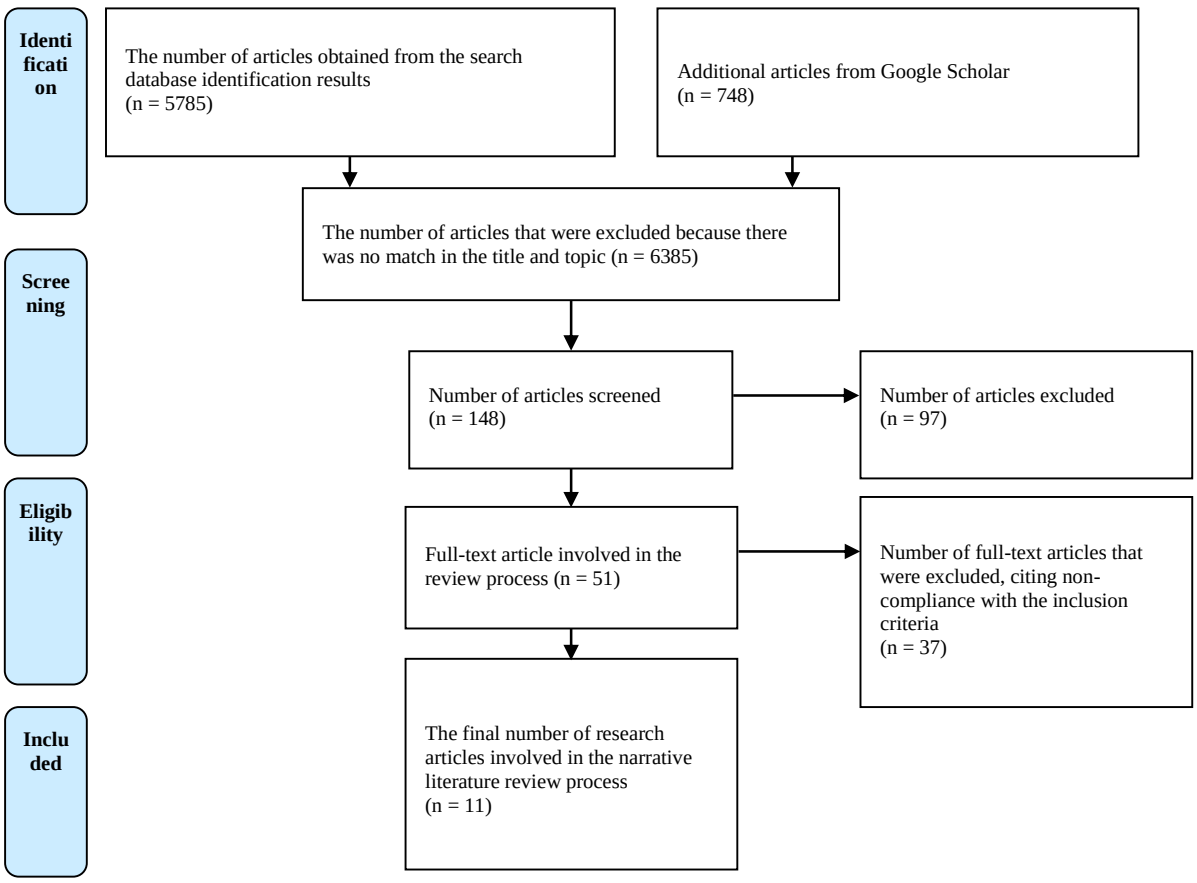

Figure 1. Diagram of the review process using PRISMA

3. RESULTS

The results of the article search obtained primary research articles including prevalence studies (1), cross-sectional studies (1), retrospective cohort studies (2), prospective cohort

DOI: http://dx.doi.org/10.17509/jpki.v7i1.26804
e-ISSN 2477-3743 | p-ISSN 2541-0024

studies (1), randomized, prospective, comparative studies (1), study reports (2). A quasi-experimental study (2), a randomized clinical trial (1). The review of articles used as literature in this study is presented in the table 1.

Table 1. The Result of Article

Citations	Population & Respondents	Method	Results and Discussion	Conclusion	Limitations
(Belomazheva-dimitova, 2020)	30 patients with intra articular fracture.	Prevalence study	The results and discussion of research from this journal states that muscle strength in patients with elbow fracture in Bulgaria has decreased muscle strength after being measured by the manual muscle testing method, it can be seen from the elbow extension movement with a score of 3 as much as 56.7%, which should be a normal score of muscle strength is 5.	The conclusion of this study is a decrease in muscle strength in patients with elbow fractures.	The limitation of this study is the small number of samples.
(Gao et al., 2015)	The number of respondents is 243	Cross-sectional study	The results and discussion of this study state that the fracture patients who experienced a decrease in muscle strength were assessed using the MMT method as much as 37% of the 234 fracture patients in Sichuan, China.	This study concludes that after assessing muscle strength with the MMT method in fracture patients in Sichuan China, there was a decrease in muscle strength in fracture patients.	
(Cho, Lee, & Lee, 2019)	The number of respondents is 17.	Quasi-experimental study	The results of this study state the muscle strength of fracture patients who were undergoing conservative treatment after examination with the MMT method obtained a score of zero ~ trace strength in 11 patients and poor ~ fair in 6 patients with fractures.	The conclusion of this study that fracture patients who were undergoing conservative treatment experienced a decrease in muscle strength.	The limitation of this study is the small sample size with a retrospective design.
(Ostermann et al., 2019)	50 Respondents	Prospective cohort study	The results of the study show data on the muscle strength of respondents assessed by the MMT method, as many as 25 people recovered within 24 weeks and for all respondents, it took 52 weeks to recover muscle strength.	This study concludes that the return of muscle strength after previously experiencing a decrease in muscle strength requires time for the recovery process.	A limitation of this study is the small sample size, analyzing a non-homogeneous patient population, using data collected by multiple examiners over two decades.
(Shah dan Shinde, 2018)	30 Respondents	Randomize, prospective, comparative studies	The results of this study are an increase in post-therapy in fracture patients with VAS results from $p \leq 0.0001$, ROM score $p \leq 0.0001$, MMT score $p \leq 0.0001$, and DASH score $p \leq 0.0001$	This study concludes that the assessment results with the VAS, MMT, ROM, and DASH instruments show a relationship between decreased muscle strength and the incidence of fractures.	The limitation of this study is the small number of samples.

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e-ISSN 2477-3743 | p-ISSN 2541-0024

(Bertelli, Soldado, & Ghizoni, 2018)	The number of respondents in seven patients with an average age (4-11 years).	Retrospecti ve cohort study.	The results of radial nerve grafting in 7 children with distal humerus fractures were then tested using MMT, wrist extension motion with a score of 4, and finger extension with a score of 4 in all patients.	This research concludes that when researching muscle strength using the MMT method, the scores were not optimal for the muscle strength of the respondents.	The limitation of this study is the small number of patients and does not assess the sensory deficit either before or after surgery.

Table 1. The Result of Article (*Advanced*)

Citations	**Population & Respondents**	**Method**	**Results and Discussion**	**Conclusion**	**Limitations**
(Naoki et al., 2018)	Female patient aged 60 years.	Study report	The examination results using the MMT method obtained a score of 4 for the quadriceps muscle of the right lower limb and hamstring.	This study concludes that the patient's muscle strength decreased to 4 from the total MMT score of 5, so it can be concluded that there was a decrease in the patient's muscle strength.	The limitation of this study is the small number of samples.
(Khosrojerdi, Tajabadi, Amadani, Akrami, & Tadayonfar, 2018)	The number of respondents is 120 aged 15-49 years.	A randomized clinical trial	This study aims to determine changes in pain before and after isometric exercises and see an increase in muscle strength in respondents using the MMT method.	This study concludes that isometric exercises are effective in reducing pain and restoring muscle strength.	The limitation of this study is the limitations in the movements performed by the respondent.
(Iwamoto et al., 2017)	The number of respondents is 10, with 3 males and 7 females with an average age of 23-85.	Retrospecti ve study.	The study results stated that the muscle strength of 7 respondents was 5, while 3 respondents experienced an imperfect muscle strength score of 4.	This study concludes that patients who experience fractures and undergo treatment still need time to recover their original muscle strength.	This study cannot use a retrospective design with a small number of patients, elbow extension in the study was evaluated by qualitative methods using MMT.
(Shinohara, Takahashi, & Hirata, 2017)	The respondent is a 33-year-old male.	Report study	The assessment of muscle strength in fracture patients was assessed by manual muscle testing (MMT) method showing a score of 5 after going through a recovery period from the installation of a volar lacking plate.	This study concludes that there is a decrease in muscle strength due to fracture of the distal radius.	The limitation of this study is the small number of samples.
(Patane et al., 2019)	The number of respondents is 10 with ages between 5-11 years.	Quasi-experimental study	The results and discussion of the study showed an increase in range of motion, muscle strength, and functional ability with a p-value <0.0001.	The conclusion of this study is an increase in range of motion and muscle strength in patients undergoing traditional game therapy.	The limitation of this study is the use of a small sample size and a short study period.

4. DISCUSSION

Decrease in muscle strength in fracture patients assessed by the Manual Muscle Testing (MMT) method, which was synthesized from the literature obtained, is summarized into 8 topics,

DOI: http://dx.doi.org/10.17509/jpki.v7i1.26804
e-ISSN 2477-3743 | p-ISSN 2541-0024

namely the cause of fracture, the location of the fracture, the degree of injury to the fracture, factors that affect bone healing in the fracture, decreased muscle strength fractures, differences in muscle recovery in fracture, stroke and spinal cord injury patients, Manual Muscle Testing (MMT) in fracture, stroke, and spinal cord injury patients. Manual muscle testing (MMT) scale was for fracture, stroke, and spinal cord injury patients.

Causes of Fractures

Fractures can be caused due to traumatic injury to the bone and pathological factors (Belomazheva-dimitova, 2020; Ostermann et al.; Patane et al, 2019; Shah dan Shinde; Bertelli et al, Naoki et al, 2018; Iwamoto et al, 2017). According to Sachdeva in (Jitowiyono dan Kristiyanasari, 2010), the causes of fracture can be divided into two, namely 1) traumatic fracture; 2) pathological fracture. Traumatic fracture is a fracture that occurs as a result of direct injury or indirect injury, while pathological fractures are fractures caused due to a process of disease (Jitowiyono dan Kristiyanasari, 2010).

Fracture Location

Fracture is a loss of bone continuity when a load is placed on the bone that exceeds its biological capacity (Swearingen, 2016). Limb fracture occurs in components of the upper and lower extremities (Parahita, Kurniyanta, Sakit, Pusat, & Denpasar, 2011). The fracture types based on their location are divided into upper limb fractures such as humeral and radius fractures, as well as lower limb fractures such as femoral fractures (Shah dan Shinde., Bertelli et al., Khosrojerdi et al., 2018; Belomazheva-Dimitrova, 2020; Ostermann et al; Patane et al., Cho et al., 2019; Iwamoto et al., Shinohara et al., 2017).

Degree of Injury in Fracture

Fracture classification can explain the extent of the fracture (Jitowiyono dan Kristiyanasari, 2010). The difference in injury conditions in the fracture can be seen from the classification of open or closed fractures (Ostermann et al., 2019; Bertelli et al., 2018; Iwamoto et al., 2017). According to (Jitowiyono and Kristiyanasari, 2010; Kenneth, 20e20) the classification of open fractures is divided into grade I, grade II, grade IIIA, grade IIIB, and grade IIIC, while the classification of closed fractures is divided into degrees 0, grade I, grade II and grade III. The following is a classification of open fractures according to Gustilo & Anderson in (Kenneth et al, 2020):

Table 2. Classification of Open Fractures

Degree	Wounds	Contamination Level	Soft Tissue Wounds	Bone Wounds
I	The length of the wound <1 cm	Clean from contamination	Minimal	Simple, minimal
II	The length of the wound is> 1 cm	Moderate	Moderate, some muscles were injured	Moderate
IIIA	Generally, the length of the wound is> 10cm	High	Most of it was injured	Fragmented fracture

DOI: http://dx.doi.org/10.17509/jpki.v7i1.26804
e-ISSN 2477-3743 | p-ISSN 2541-0024

IIIB	Generally, the length of the wound is> 10cm	High	Very injured	Fragmented fracture, presence of contamination
IIIC	Generally, the length of the wound is> 10cm	High	Severely crushed and an injury to a blood vessel	A contaminated fracture, a labored covering of bone, usually requires soft tissue reconstruction.

Meanwhile, the closed fracture classification according to Tscherne (Kenneth et al, 2020):

Table 3. Classification of Closed Fractures

Degree	Injury
0	Indirect force injury with negligible soft tissue damage
I	Closed fractures are caused by low to moderate energy mechanisms, with superficial abrasion or soft tissue contusions.
II	Closed fracture with muscle contusions of possibly deep condition, moderate to severe contaminated cultured abrasions and bone injury, high risk of compartment syndrome.
III	Soft tissue injured by avulsion, arterial obstruction, or compartment syndrome

Factors Affecting Bone Healing In Fractures

Factors that can affect bone healing in fractures are the cause of injury to the fracture, the location of the fracture, and the type of injury in the fracture (Ostermann et al., 2019). Pathophysiology of bone healing according to (Lemon, 2015) namely 1) bone injury; 2) fibrocartilaginous callus formation; 3) bone callus formation, and 4) bone remodeling. At the stage of bone injury, the blood vessels in the bone and surrounding soft tissue are torn and begin to bleed to form a hematoma. Next is the fibrocartilaginous callus formation phase that can occur within 48 hours. Within 48 hours, new fibroblasts and capillaries grow into the fracture and granulation tissue, gradually replacing the hematoma. In the fibrocartilaginous callus formation stage, osteoblasts form, proliferating to form fibrocartilaginous callus, and osteoblasts that combine bone fragments to form bone. Then is the stage of bone callus formation, where osteoblasts continue to increase and synthesize collagen fibers and bone matrix which gradually form a spongy bone mass. The process of bone callus formation lasts for 2-3 months. The last stage of the pathophysiology of bone healing is remodeling. At this stage, the osteoblasts continue to form bone sponges that will form solid bone over time, and over time, the parts of the bone that have undergone the healing process will resemble parts of the bone that are not injured (Lemon, 2015).

The cause of the fracture can influence the bone healing process, for example, fractures due to traumatic injuries or pathological fractures (Belomazheva-dimitova, 2020; Ostermann et al.; Patane et al, 2019; Shah dan Shinde; Bertelli et al., Naoki et al., 2018; Iwamoto et al, 2017). From explaining the previous bone healing process, fractures caused by traumatic bone injuries can be treated with fracture management such as surgery (Lemon, 2015). After the operation on the patient, over time the fractures in the bones will heal and return to normal. However, fractures caused by pathological fractures such as rheumatoid arthritis and osteoporosis will not heal and return to normal. Rheumatoid arthritis is a chronic autoimmune inflammatory disease and osteoporosis is a bone loss disease that cannot undergo the fibrocartilaginous callus formation

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e-ISSN 2477-3743 | p-ISSN 2541-0024

process and bone callus formation at the pathophysiological stage of bone healing (Naoki et al., 2018). According to research (Adawiyah & Selviastuti, 2014) states that pathological conditions such as osteoporosis cannot be cured.

In addition to the cause of the fracture, a factor that affects the fracture healing process is the location of the fracture (Ostermann et al., 2019; Bertelli et al., 2018; Shinohara et al., 2017). There are several fractures that can be followed by nerve injury and the most common occurs in the humeral shaft, *distal humerus, and distal radius* (Ostermann et al., 2019; Bertelli et al., 2018; Shinohara et al., 2017). There is a radial nerve in the humeral bone in the posterior humeral facies and radius fractures; there is often compartment syndrome that can trigger fractures with nerve injury (Lemon., 2015; Azlar., 2017; Karna., 2018). Compartment syndrome is a condition that occurs due to increased pressure in the muscle compartment so that which can cause muscle injury to muscle tissue, blood vessels and nerves (Parahita et al., 2011).

The wound healing process can be influenced by the type of wound (Ostermann et al., 2019). Open fractures that undergo ORIF action on humeral fractures are thought to cause nerve injury, tissue damage, require a long operation time, and a lot of blood loss (Ostermann et al., 2019). The classification of open fractures supports this according to Gustilo and Anderson in (Kenneth et al., 2020) to 1) grade I; 2) grade II, grade III (grade IIIA, grade IIIB, and grade IIIC), which states that the condition of the fracture is getting worse according to the degree, which is marked by the depth of the wound, soft tissue damage, and blood vessel injury. Closed fractures can also experience a high degree of severity, such as compartment syndrome (Ostermann et al., 2019). There's closed fracture classification (Kenneth et al., 2020) is divided into 1) degrees 0; 2) degree I; 3) grade II and 4) grade III, which is characterized by soft tissue damage, avulsion, and compartment syndrome.

Decreased Muscle Strength In Fractures

The decrease in muscle strength in fracture patients can be seen from the MMT score in each fracture patient (Belomazheva-dimitova, 2020; Cho et al.,; Ostermann et al., 2019; Bertelli et al.,; Naoki et al., 2018; Iwamoto et al., 2017; Gao et al., 2015). The decrease in muscle strength in fracture patients is due to the fracture due to the fracture which takes time to recover (Lemon, 2015). Muscle strength in fracture patients can be seen from the bad muscle strength score of the total muscle strength score, which is 5 on the assessment by the MMT method in fracture patients (Naoki et al., 2018; Cho et als., 2019).

Differences in Muscle Recovery in Patients with Fracture, Stroke, and Spinal Cord Injury

The process of bone healing in fracture patients according to (Lemon, 2015) namely 1) bone injury; 2) fibrocartilaginous callus formation; 3) bone callus formation, and 4) bone remodeling. The process of bone injury occurs when the bone is traumatized, and then the fibrocartilaginous callus formation process is formed within 48 hours. The bone callus formation process occurs within 3-4 weeks after the fibrocartilaginous callus formation process takes between 2-3 months, and the bone remodeling process takes longer. Longer than the previous

DOI: http://dx.doi.org/10.17509/jpki.v7i1.26804
e-ISSN 2477-3743 | p-ISSN 2541-0024

process. The pathophysiology of bone healing can affect the length of muscle recovery time in fractures (Ostermann et al., 2019). The assessment of muscle strength using the MMT method can be carried out in fracture patients (Department of Rehabilitation Services, 2010), which is 2-3 days after surgery, which is the same as early mobilization. Early mobilization can minimize complications that occur in fracture patients (Timothy Kenyon-Smith, 2019). MMT muscle strength examination is needed to determine muscle strength. It is useful as a measuring tool for the success of therapy as seen from the increased muscle strength score after therapy in fracture patients (Khosrojerdi et al., 2018; Patane, 2019; Belomazheva-dimitova, 2020).

Manual Muscle Testing (MMT) in Fracture, Stroke, and Spinal Cord Injury Patients

Manual Muscle Testing (MMT) is a method of assessing muscle strength that is commonly used because it is a reliable assessment of muscle strength and without the need for additional tools to practice it and one is a method of assessing muscle strength that not only assesses muscle strength in fracture patients but also (stroke, post-polio syndrome, and spinal cord injury) (Belomazheva-dimitova, 2020; Ostermann et al., 2019; Naoki et al. ; Bertelli et al., 2018; Shinohara et al., 2017) this is relevant to research (Abdurachman et al, 2017; Cuthbert&Jr., 2007; Ms et al., 2011) and (Cuthbert&Jr., 2007) which state that MMT is a universal method of assessing muscle strength. MMT in fracture patients uses flexion, extension, rotation, abduction, plantar flexion, and dorsiflexion (Belomazheva-dimitova, 2020; Timothy Kenyon-Smith, 2019; Shah dan Shinde, 2018; Iwamoto et al., ; Abdurachman et al, 2017). So it can be concluded that the movements needed to assess muscle strength are adjusted to the practitioner who is doing them, without leaving the correct rules or ways of doing MMT, for example, such as how to do flexion or extension movements.

Measurement of muscle strength in stroke patients and patients with spinal cord injury also uses the MMT method to assess muscle strength using this method is a guaranteed method of reliability. (Putranto et al., 2016; J. Lee et al., 2017; Bye et al., 2019). Sam as MMT in fracture patients, MMT in stroke patients, and spinal cord injury patients also perform MMT movements such as flexion and extension (Putranto et al., 2016; J. Lee et al, 2017; Bye et al., 2019).

Manual Muscle Testing (MMT) Scale for Fracture, Stroke, and Spinal Cord Injury patients

The scale of muscle strength assessment in patients with fracture, stroke, and spinal cord injury was the same as there was no difference in the same movement in the MMT method. There is a Medical Research Council (MRC) muscle strength rating scale (Bertelli et al., 2018; Putranto et al., 2016). Besides, there is also a Daniel & Wothingham muscle strength assessment scale used in the study (Cho et al.,; Ostermann et al., 2019; Khosrojerdi et al., 2018). There is no difference in the scale of the Medical Research Council (MRC) and Daniel & Worthingham's muscle strength assessment, but the use of the scale is following the practitioner or physiotherapist who assesses muscle strength. Table 5 describes assessment of the MMT score using the Medical Research Council (MRC) and Daniel & Worthingham's:

DOI: http://dx.doi.org/10.17509/jpki.v7i1.26804
e-ISSN 2477-3743 | p-ISSN 2541-0024

Table 4. Medical Research Council (MRC) & Daniel & Worthingham's Muscle Strength Scale

Daniel & Worthingham's	MRC Scale	Description
0	0	There is no movement / total paralysis
Trace (T)	1	Visible or palpable muscle contraction
Poor (P)	2	Able to shift but unable to resist Earth's gravity
Fair (F)	3	Able to defy Earth's gravity but unable to resist resistance
Good (G)	4	Able to defy Earth's gravity but only able to resist moderate resistance
Normal (N)	5	Able to defy Earth's gravity and able to fight full resistance

Therefore, in the future, it is necessary to conduct direct research on the assessment of muscle strength in fracture patients to determine the decrease in muscle strength so that fracture patients know their condition and are aware of the importance of therapy that can accelerate healing.

5. CONCLUSIONS AND SUGGESTIONS

The Manual Muscle Testing (MMT) method is a method of assessing muscle strength that is reliable and in practice, it does not require additional tools and is universal, which can be used in fracture and non-fracture patients (stroke and spinal cord injury) after assessing muscle strength in fractured patients. Shows a decrease in muscle strength in fractured and non-fractured patients (stroke and spinal cord injury). Knowing that there is a decrease in muscle strength after measuring muscle strength with the MMT method can determine the proper therapy process for the healing process of muscle strength after fracture and non-fracture healing management.

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DOI: http://dx.doi.org/10.17509/jpki.v7i1.26804
e-ISSN 2477-3743 | p-ISSN 2541-0024

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DOI: http://dx.doi.org/10.17509/jpki.v7i1.26804
e-ISSN 2477-3743 | p-ISSN 2541-0024

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