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Pinch Technique and Pinch Force: A Literature Review of Their Importance in Carpal Tunnel Syndrome

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ABSTRACT

Carpal tunnel syndrome or CTS is known as the most common peripheral entrapment neuropathy. It is caused by chronic compression of the median nerve in the carpal tunnel area. Previous studies suggest that CTS patients tend to exert higher grip forces than those of healthy individuals. The effects of CTS on the hand grip actions are influenced by the type of tasks, number of digits being engaged and degree of nerve impairment. Consequently, patients do not have normal full control of their hand functions. This brief literature review emphasises on the importance of the different types of pinch techniques and pinch force levels in CTS. The pinch techniques covered in this literature review are three-jaw chuck pinch, lateral pinch (key pinch grip) and pulp-2 pinch. The pinch force refers to the force generated on the fingers while performing tasks using the three pinch techniques mentioned.

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INTRODUCTION

Many past studies have suggested that carpal tunnel syndrome or CTS is one of the most prevalent peripheral entrapment neuropathy induced by chronic median nerve compression (Bahou, 2001; De Smet *et al*., 2004; Keir *et al*., 1997; Li *et al*., 2014; Liu *et al*., 2003; Lowe and Freivalds, 1999; Rosenbaum and L., 2002; Sayles, 2007). If this nerve compression is prolonged in the carpal tunnel, the patient will develop sensory symptoms, for example paresthesia (tingling or itching sensation), numbness, pain and motor symptoms such as stiffness, and also weakness of hand capabilities (Li *et al*., 2014; Rosenbaum and L., 2002). The incidence of the above symptoms would influence the performance and efficiency of the patient's ability in performing day-to-day tasks. The decrease in performances on strength and endurance is especially more alarming and critical when the patient depends on the usage of hands and fingers when performing tasks at the workplace.

Previous researchers (Lowe and Freivalds, 1999) have found that CTS patients exerted greater grip force than healthy individuals when holding a tool using a two digit precision grip which involved the thumb and index finger. Researchers have also posited that in certain working conditions, a force-precision trade-off situation would occur (Finneran and O'Sullivan, 2013). It was found that more powerful grip techniques are less precise in terms of task performance (Au and Keir, 2007; Finneran and O'Sullivan, 2013; Wikström *et al*., 1991). Those researchers found that tasks which required higher precision performance were better achieved when the grip technique used was a lesser powerful grip type. Based on these findings, the usage of an unsuitable and incorrect grip technique which requires grip force can affect the quality and performance of a task. Therefore, these findings were useful especially to assembly and manufacturing companies which required their manual workers to perform effectively and efficiently the assigned tasks.

However, while there have been some previous research and findings related to the effects of grip technique on the grip force of healthy individuals, few studies review the importance of different pinch techniques and pinch force levels among CTS patients (Ellis *et al*., 2004; Enders and Seo, 2011; Finneran and O'Sullivan, 2013; Freund *et al*., 2002; Huysmans *et al*., 2008; Seo and Armstrong, 2008; Shivers *et al*., 2002).

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Literature Review:

Carpal tunnel syndrome or CTS is a type of cumulative trauma disorder that is due to an entrapment of the median nerve at the wrist (Bahou, 2001; Cossey and Stranks, 2003; De Smet *et al*., 2004; Li *et al*., 2014; Lowe and Freivalds, 1999; Rosenbaum and L., 2002; Sayles, 2007). It is the most common and widely known peripheral entrapment neuropathy (Bahou, 2001; Li *et al*., 2014; Lowe and Freivalds, 1999; Rosenbaum and L., 2002; Watts and McEachan, 2006). Typical symptoms and signs are numbness, tingling or burning pain in the median nerve-innervated finger (anterior surface of the first three digits and the radial portion of the ring finger), and nocturnal pain and paresthesia (Isolani *et al*., 2002; Liu *et al*., 2003; Lo *et al*., 2002).

High prevalence of CTS has been observed in manufacturing (42 - 93 % for both sexes), construction (66 % for men) and personal service industries (66 % for women) and in the trade and commerce sectors (49 % for women) (Jagga *et al*., 2011). The occupations which have increased risk for CTS include manual handling assembly workers in food industry, especially in meat and fish processing section, garment industry, boot and shoe manufacturing, supermarket cashiers, hand-made carpet manufacturing, fishnet and railroad workers (Kutluhan *et al*., 2009).

A pinch grip is defined as the act of gripping or squeezing something in between the thumb and the finger (Trew and Everett, 2005). The muscles that contribute to pinch grips include both the intrinsic and extrinsic musculature of the hand and forearm (Dempsey and Ayoub, 1996). While an entire hand grip reflects the gross hand power of the human hand, a pinch grip is a determinant of thumb function (Lau and Ip, 2006).

A pinch grip is very much different from a power grip which is principally utilised to grip an object within the palm of the hand with a force from the thumb opposing the combined forces from other fingers (Kumar, 2008). Figure 1 shows an illustration to highlight the difference between a pinch grip and a power grip. Figure 1 (a) represents a typical power grip whereas Figure 1 (b) represents a typical pinch grip. Unlike the power grip which uses almost the whole area of the palm, a pinch grip involves the holding or squeezing of an item without contacting the palm.

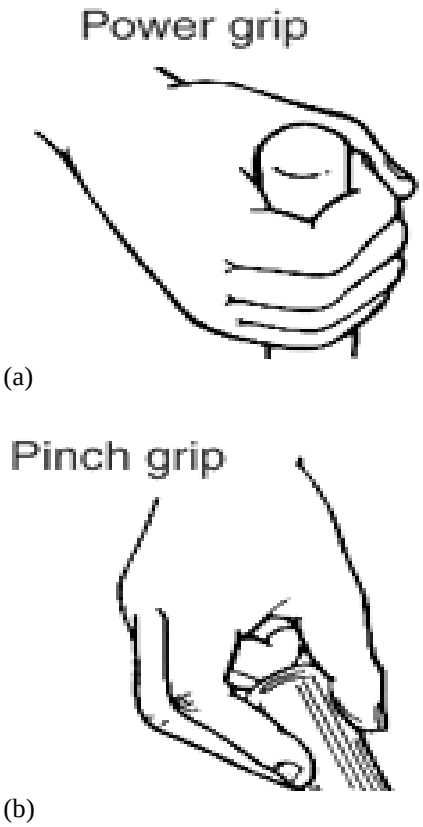

Fig. 1: Pinch Grip and Power Grip (Dean *et al*., 2004)

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A pinch technique is an orderly procedure of gripping something with a thumb and finger (Business Dictionary, 2014; Merriam-Webster, 2014; Trew and Everett, 2005). With reference to the definition of movement technique, pinch technique also refers to the pinch control method used by an individual to cope with various pinching conditions (Lussanet *et al*., 2002). Researchers who studied the use of pinch techniques among individuals with cumulative trauma disorders such as CTS found that fingertip pinch techniques appear to increase the risk of upper extremity cumulative trauma disorders and causes chronic pain in the wrist and digits (Ellis *et al*., 2004).

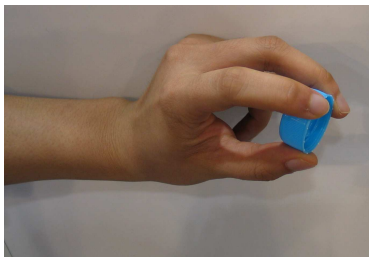
Some researchers have even proposed classifications and taxonomies of different grasp and pinch techniques used by adults during the performance of various daily living activities (Edwards *et al*., 2002; Vergara *et al*., 2014). Vergara *et al*. (2014) proposed 9 different types of techniques which are described in Table 1, though these 9 techniques are a mixture of both pinches and grasps.

Table 1: Description of the Different Pinch and Grasp Techniques (Vergara *et al*., 2014)

No.	Name	Description
1	Cylindrical grasp	Involves the palm. The thumb directly opposes the fingers (in abduction or neutral).
2	Oblique palmar grasp	Deviation of the Cylindrical grasp that involves the palm, but leaves the thumb adducted.
3	Hook grasp	Does not involve the palm and thumb. The fingers bear the object's weight.
4	Lumbrical grasp	Involves the thumb and proximal section of the fingers, but does not involve the palm.
5	Intermediate power-precision grasp	Involves an extent of the palm, but requires stabilisation of the grasp from both the thumb and the index fingers.
6	Pinch grasp	Uses both the thumb and fingertips (either one or more).
7	Lateral Pinch	Uses the lateral aspect of the fingers (either one or more), and normally with the thumb as well.
8	Special pinch	Involves the thumb, lateral section of some finger and the fingertips of other fingers.
9	Non-prehensile grasp	Objects are manipulated without grasping them.

The common pinch techniques in manufacturing and daily living activities include the three-jaw chuck pinch, lateral pinch and pulp-2 pinch (Ellis *et al*., 2004; Shih and Ou, 2005; Valero-Cuevas *et al*., 2003). A three-jaw chuck pinch is a pinch technique performed by placing the object between the tip of the distal phalanx of the finger(s) and the pad of the thumb (Ellis *et al*., 2004). A lateral pinch is defined as a pinch technique where force is generated between the pad of the thumb and the radial side of the middle phalanx of the index finger (Dempsey and Ayoub, 1996; Smaby *et al*., 2004). A pulp-2 pinch is described as a pinch technique with force generation between the pad of the thumb and the pad of the fore finger (Dempsey and Ayoub, 1996).

Figure 2 shows snapshots of the aforementioned pinch techniques, where Figure 2 (a) represents the three-jaw chuck pinch, Figure 2 (b) the lateral pinch and Figure 2 (c) the pulp-2 pinch.



(a)

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(b)

(c)

Fig. 2: Three commonly applied pinch techniques

Researchers have posited that the three-jaw chuck pinch is the pinch technique that generates the least amount of effort when gripping small knobs as compared to the lateral and pulp-2 pinch technique (Ng *et al*., 2014). This postulation is also agreeable with the findings of Imrhan and Rahman (1995), who further elucidate that the lateral pinch is weaker than the three-jaw chuck pinch, but stronger than the pulp-2 pinch. In fact, earlier researchers in the field such as Swanson *et al*. (1974) also concurred that the three-jaw chuck pinch generates a higher mean pinch force compared to the lateral pinch.

CTS may cause reduced pinch strength for a variety of reasons. Muscle tension–related grip and pinch strength loss in patients with CTS may be a result of the loss of metacarpophalangeal (MCP) joint flexion power from deinnervation of the first and second lumbricals, as the extrinsic flexors are innervated higher in the forearm (Oatis, 2004). Certain grip and pinch techniques (lateral and palmar) are commonly used to assess motor outcomes after CTS surgery (Geere *et al*., 2007). Hence, pinch techniques play an important role in CTS.

A pinch force refers to the measure of actual distributed force acting on the fingers when pinching an object (Freund *et al*., 2002). Most daily hand-related tasks require the ability to produce, maintain and regulate pinch force to elaborately manipulate objects (Iyengar *et al*., 2009). It is common that the task not only required the person to induce a minimum force to enable it to be carried out, but also to maintain that minimum force for a certain duration to fully complete the required task. In other words, the endurance of the manual worker in performing the required task is critical in accomplishing the planned task successfully. This is an important factor to consider, especially in the assembly and manufacturing area because manual workers typically work in eight-hour shifts. Pinch forces are also applied to produce thrust forces and torque to prevent objects from rotating along the fingers and sliding away from them (Seo and Armstrong, 2008). In this case, the force created is acting like a counter-friction force to prevent slippage between the finger and the object being handled. High-force pinching tasks in many occupational activities are common risk factors associated with the development of cumulative trauma disorders such as CTS. Most epidemiological studies have pointed out that the use of pinch grips at high loads are positively related to CTS (Keir and Wells, 1999; Shivers *et al*., 2002).

Studies showed that size and torque direction play a significant role in pinch force generation (Ng *et al*., 2015a; Ng *et al*., 2015b). For instance, Ng *et al*. (2015a) asserted that the pinch force exerted on a medium-sized screw knob is 3.37 % higher than the force exerted on a small-sized screw knob and 6.00 % higher than that of a large-sized screw knob. The researchers posited that the inertia of the large knobs

may have reduced the external force requirements to pinch and twist the knob and this led to the decrease in pinch force. The findings and knowledge which have been gained from these researchers have been useful in understanding of the importance of ergonomics in the optimum design of suitable screw knobs, especially in machines and equipment used in the manufacturing industry.

In association to torque direction effects in pinch force, researchers also found that a pinch force exerted in a clockwise torque direction is about 80g, which reduces by 3.4 % with the use of the counterclockwise direction (Ng *et al*., 2015b). The preceding findings matched the theories of other researchers (Seo and Armstrong, 2006; Seo *et al*., 2007), which concurred that the skin friction produced by turning the object in a clockwise torque direction flexed the distal phalanges to increase the normal force and torque generation (Pheasant and O'Neill, 1975; Seo *et al*., 2007; Seo *et al*., 2008a; Seo *et al*., 2008b).

Pinch force generation also plays a considerable role in CTS since the clinical manifestations of CTS include sensory loss and hand weakness (Atalay *et al*., 2011; Fernandez-de-las-Penas *et al*., 2009). The lumbricals, one of the intrinsic muscle groups of the hand, play an important role in both these manifestations and originate on the tendons of the flexor digitorum profundus (FDP) (Baker *et al*., 2013). During a pinch grip, when the FDP flexes the fingers, it retracts through the carpal tunnel and pulls the lumbricals proximally (Evans, 1997). This would indirectly affect the area of the carpal tunnel of the hand and lead to an increase in the pressure present in the carpal tunnel. An increase in carpal tunnel pressure has been found to be linked to an increase in the symptoms of CTS. Hence, high pinch force generation can potentially increase carpal tunnel pressure and contribute to the symptoms of CTS.

Conclusion:

This literature review deliberated the importance of different types of pinch techniques and pinch force generation in CTS. Although the literature review provided is brief, it is useful as a preliminary research information on underlying pinch parameters to be further investigated with regard to CTS. This literature review also alluded that the lateral pinch technique presents a major role in CTS as it is usually used to assess motor outcomes after CTS surgery. The literature review also pointed out that pinch force plays an important role in CTS since a variance in pinch force can retract the carpal tunnel and alter the carpal tunnel pressure to emit different levels of symptoms in CTS.

This literature review serves as a key reference for preliminary studies on CTS patients, and can be further expounded in occupations where the disorder is increasingly prevalent, such as assembly, manufacturing and production work. Although, further data collection and analyses on the pinch forces of participants from these industries are required to solidify the claims of this literature review, a new avenue of research towards the investigation of pinch techniques and pinch force in CTS subjects is pointed out. It is hoped that future experimental and empirical studies in the similar area and scope can be carried out, especially in the field of manufacturing and operations, in order to justify the significance of the roles of pinch techniques and pinch force in CTS.

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