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A PRELIMINARY INVESTIGATION ON THE GRIP FORCE APPLIED ON A CYLINDRICAL HANDLE

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INTRODUCTION

Hand grip force is an important factor for risk assessment of hand musculoskeletal disorders. Grip strength is also one of the important indices for the diagnosis of hand disorders such as hand-arm vibration syndrome and carpel tunnel syndrome. Therefore, a considerable number of studies on grip force or strength have been reported. However, it remains an important issue how to quantify the grip force or strength. Conventionally, the grip force is measured using a handle that measures the applied force in two opposite directions in the grip action. However, it has been demonstrated that the grip force applied on a cylindrical handle is not uniformly distributed in each orientation of the hand [1]. Therefore, the grip force measured in a specific direction may not be an accurate measure of the grip effort. Alternatively, the total grip force has been proposed to serve as the grip measure [2]. The major objectives of this study are as follows: (i) to develop a cylindrical instrumented handle that can be used to perform the measurement of the total grip force and to characterize its distribution around the handle; (ii) to estimate the principle grip force and direction; and (iii) to investigate the relationship between the total grip force and that measured on a Jamar handle.

METHODS

As shown in Fig. 1, a new instrumented handle was designed and constructed. Similar to the handle reported by Nicol and Chadwick [3], the new handle structure includes six evenly distributed measuring beams. Whereas the previously reported handle measured the grip force through bending gages, this new handle utilizes the shear force measurement principle [4], which can avoid the effect of the grip location on the measurement [5]. The new handle has a diameter of 40 mm and has a 1 mm gap between each pair of arms. Each arm of the handle was placed in a horizontal mount and calibrated to within ±1%

Fig. 1: 6-Arm grip handle and grip posture.

(350 N max) using various weights in the range of 11 to 168 N. The calibration weights were placed at several locations along the arm to ensure that the shear force measurements were linear.

Five male adult subjects participated in the pilot experiment. Only the right hand was used in the testing. The handle was suspended from a string to make certain no push or pull forces were measured during the tests. The hand grip posture is also shown in Fig. 1. To minimize grip orientation variations, adhesive markers were affixed on the thenar eminence of each subject. These markers were aligned with a marker on the handle during each trial. Subjects were advised to

apply a maximum grip force on the handle. A Jamar handle was also used to collect a maximum grip force for comparison. Three trials were performed on each handle for each subject. The measurement sequence for the two handles was randomized for each subject. The measured force components on half of the cylindrical handle were projected to an axis across the center of the handle and integrated to calculate the grip force on that axis to find the grip force in a given direction. The total grip force was taken as a sum of the forces measured on the six beams. The principal grip force and direction were estimated using the equations proposed by Dong et al [1].

RESULTS AND DISCUSSION

The average grip force of the five subjects, along with the standard deviation for each arm of the handle, is shown in Figure 2. The maximum grip force was on Arm 5, where the fingertips were located during testing. Similar to that observed in the previous study [1], the sum of the forces measured on the three arms on half of the handle is generally not equal to that measured on the other three arms. The maximum difference could be up to 22%. These observations confirm that there is a tangential component in the grip action, which may primarily result from the friction between the hand and handle. However, the normal component may sufficiently represent the grip effort on the cylindrical handle.

The average total grip force was 959 N. This was approximately twice the average grip force (475 N) measured with the Jamar handle. The mean standard deviation for the 6-arm grip handle was 52 N, while the mean standard deviation for Jamar handle was 134 N. The maximum Jamar handle grip force was 585 N, while the minimum was 375 N. The estimated principle grip direction was near the fingertips area, which is consistent with the finding reported in the previous studies [1,2]. This data suggests that the 6-arm shear force handle is a viable means of gathering data that can be used to evaluate grip force distribution and total grip force.

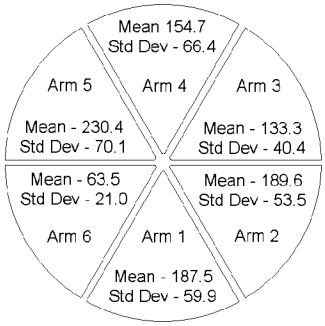

Fig. 2: Mean measured force and standard deviation for each arm (N).

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