OPINION ARTICLE

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IMPLICATIONS OF PREDICTING HAND PROFICIENCY FROM HAND FUNCTION TESTS AND ANTHROPOMETRIC MEASUREMENTS

Dr. P. Mandela Idenya

Correspondence to Dr. Pamela Mandela Idenya, MBChB, MMed, MPH, Senior Lecturer, University of Nairobi, School of Medicine, Department of Human Anatomy, Chiromo Campus, P. O. Box 19676-00202, KNH, Nairobi Kenya. Email: pamela.idenya@uonbi.ac.ke Mobile: +254(0)733619815

ABSTRACT

The successful performance of everyday activities depends largely on the ability to perform purposeful movements efficiently and precisely. These dextrous movements are known to be dependent upon finely-tuned successions of synergistic muscle activity. It is possible to manipulate the environs with a high measure of hand motion suppleness using various tests. Hand function testing recognizes manual capability (dexterity), hand preference (handedness), hand performance (dominance), and grip strength (efficiency) as essential features of human control of motion. Although anthropometric measurements may be used to accurately describe the characteristics of individual hands, the large variations reported between and within individuals and populations often present a challenge. In the assessment of hand proficiency, the researcher needs to consider the usefulness of carrying out hand function tests in isolation vis-à-vis in combination one with another. This should reveal the independence of the hand function tests and at the same time identify those which can be used to predict hand proficiency for a particular population and a specific function. The use of a combination of hand function testing would lead to a better understanding and determination of hand proficiency. It would also allow for hand function to be fully assessed and the interpretations of the tests would not be restricted. The findings of such research may be applied in making a better placement of individuals in the work/training environment so that they perform tasks that put them at less risk for injury.

Keywords: Hand anthropometrics, Hand proficiency, hand preference, hand performance, manual asymmetry, dexterity asymmetry, grip-strength testing

COMMENTARY

In a recent study, several hand function tests were explored relative to hand anthropometric measurements in a select population of preclinical medical students of the University of Nairobi. This was done in a bid to identify any challenges arising from performance of hand skills challenges and possibly to predict hand proficiency in this study population. It was expected that recommendations pertaining to hand function assessment in clinical skills training would be made from the results. The measures of hand function that were considered included hand preference, hand performance, manual asymmetry, dexterity asymmetry and hand anthropometrics. These were assessed separately and then evaluated in combination with each other and also with the hand index obtained from the anthropometric measurements.

The said study largely agreed with previous researches in demonstrating that traditional techniques of evaluating hand skill proficiency can be applied in relation to hand anthropometric measurements. The results can also be used to identify students who are likely to face a hand performance-related challenge during skills training (Saleh et al., 2006 and Yamaguchi et al., 2011). The study also proved it possible to collect kinematic data concerning task-specific movements. It was noted that the outcome measures of hand movements in terms of distance (length) and quickness (speed) when using precision tools like forceps to perform a task with either hand can be recorded and analysed (Zahraee et al., 2010).

It should therefore not surprise to obtain results that show right-handers to have greater right-hand dominance whereas left-handers have negligible right-to-left differences in a measure such as the grip strength test (Petersen et al. 1989). The reality is that hand preference and grip strength test results can differ in some participants who may show higher results in the non-dominant hand (Schmidt and Toews, 1970). This has previously been demonstrated with differences between the right and left hands being especially pronounced amongst females (Petersen et al., 1989). It seems to suggest that the left-handed female is likely to face more challenges in a right-favoured skills training environment than the left-handed male counterpart.

For a researcher to be able to define and distinction between individual hand preference, measures of manual dexterity and testing for grip strength may be used independently and/or in combination with handedness inventories and self-reports. The results are expected to indicate that novice hands differ from experienced hands in the performance of a given task. For this reason, the assessment tests must put this into consideration (Yamaguchi et al., 2011).

Suffice to note that this experience-based difference is more pronounced for the left-handed than for the right-handed persons. This means that psychomotor skills in the performance of certain procedures may also be at variance regarding each hand. As Bagesteiro and Sainburg (2002) hypothesize, handedness in adults is associated with sizeable inter-limb differences in the control of limb dynamics. The study by Sainburg and Wang (2002) reported that opposite arm training progresses the initial direction of movements in the dominant arm, whereas it only improves movement accuracies in the final position of the non-dominant arm. A later study by the same team observed that performance in the dominant and non-dominant arm is distinguished by active, but not visuomotor adaptation (Wang and Sainburg, 2003). As previous studies assert, limb differences in bilateral tasks are a function of experience and an effect of practice. These must, therefore, be investigated and analysed when testing for hand proficiency in any study population.

The applicability of hand preference and hand performance testing should be of interest to the particular community. For the assessment of manual dexterity skills required during precise clinical skills training, experienced surgeons may be asked to complete questionnaires that are then used to identify a specific skill-set which is necessary for the performance of specific tasks (Baldwin et al., 1999). However, a look at recent studies indicates that there is an increased demand for a measure of task performance that is more objective, especially for junior consultants or surgeons in training (Gallagher et al., 2001; Thijssen and Schijven, 2010; Yamaguchi et al., 2011).

In order to address this need for objective measures of performance, investigations have been carried out using hand-held robotic devices (Zahraee et al., 2010) and motion analysis systems. These are now recommended to be added to the conventional techniques of evaluating skill proficiency (Saleh et al., 2006; Yamaguchi et al., 2011). These researchers have shown that motion analysis systems can accumulate kinematic (motion-based) data related to task-specific activities. The advantage of these methods is the outcome measures of task perform by either hand, since they reveal the number and path lengths of movements and the average speed of each hand.

Researchers agree that in performing specific surgical techniques, the level of proficiency is strongly influenced by the number of previously performed procedures (Baldwin et al., 1999; Saleh et al., 2006; Yamaguchi et al., 2011). However, as evidenced in the Saleh et al. (2006) study, neither hand preference nor limb differences in performance are regularly put into consideration when using motion analysis systems. It is further argued that in the study by Baldwin et al. (1999), the performance of a corneal suturing task did not yield specific limb differences. Instead, the researchers reportedly combined the performance results from both hands when conducting their exploration using a similar task. They also did not address how differences in approaches and/or selected procedures may have impacted potentially different outcomes. It is therefore likely that important data related separately to each hand may have been overlooked or deferred by their interpretations.

The other study by Yamaguchi et al. (2011) found that right-handed novice and experienced surgeons performing the same suturing and knot-tying task had identifiable limb differences between them. The use of a motion tracking system is advantageous because the kinematic data which is recorded for each hand is associated with the duration, distances of hand movements, and the average speed of forceps use. It is therefore not inconceivable that Yamaguchi et al. (2011) observed the more experienced surgeons being faster to complete the suturing and knot-tying tasks than the novice surgeons. This is likely because of the effects of long-term practice associated with experienced users, which are hand- and task-dependent. These are demonstrated by the limb differences in hand path lengths and average speeds for performing learned skilled tasks. This implies that where the same level of performance is observed between novice and experienced hands, the long-term practice effects do not explain the absence of limb differences.

Other studies have shown that each limb system has an existent specific mode of control that influences limb differences in the distance moved (hand path lengths) and the rate of movement (Bagesteiro and Sainburg, 2002). The study by Sainburg and Wang (2002) concluded that a general cognitive strategy could not be the cause of transfer of training in the adaptation of the opposite arm, which influence should be able to affect either hand equally.

In a later study, Wang and Sainburg (2003) recommended for further research to be done to distinguish whether the passing on of adaptation to active situations between limbs is similar to the visuomotor adaptations. These studies were based on the theory by Annett (1970), that in right-handed individuals distinctive movement strategies are used for the dominant and non-dominant limb systems respectively. Nonetheless, there is need for further investigations to be carried out if one should explain how the observed limb differences in a bilateral task are a result of experience and/or an effect of practice.

From the foregoing presentations, it is clear that a better understanding of hand proficiency may be determined by a combination of hand function testing. This would allow for hand preference to be fully assessed and interpretations would not be restricted. The findings may then be applied where the determination of hand preference is used to make a better placement of individuals in the work environment so that they perform tasks that put them at less risk for injury (Orbak et al., 2002).

For a study that is focused on a community of medical students, it is noted that the skills training for tasks that require manual dexterity and a high precision level may be improved by a better understanding of limb differences in the movement strategy. The identification of potential attributes among residents that contribute to skills performance can be indispensable to preceptors and academic departments in clinical skills training. These features can be used in the evaluation of competencies and are potentially practical tools for screening for entry into residency programs that require high skills training.

Future researches should consider using a larger study design in order to corroborate the following suggestions:

1. In the determination of handedness amongst a specific population study group, it is best to consider both direction and degree of hand preference. This is easily attainable using the laterality quotient measure (Geschwind Score) of the Edinburgh Handedness Inventory (EHI).
2. It is advantageous to use multiple measures when applying hand efficiency to predict hand preference because of the diversity of hand classification. However, the researcher must keep in mind that repetition in the performance of procedures potently influences the proficiency level for a specific task.
3. The standardized grip strength test is a more specific and thus better measure for predicting left-sided hand efficiency. It therefore remains the measure of choice for determining the functional efficiency of the hand.
4. When predicting hand proficiency using hand dominance tests, both handedness and hand performance testing must be used together because the EHI Geschwind Score and the Tapley and Bryden Dot-Filing tasks are not interchangeable for testing hand dominance.
5. Directional asymmetry can reasonably and reliably be determined by volumetric measures obtained by the geometric model using cylinders. This is because the use of scanned hand measurement mitigates observer bias by assuring independence on hand dominance and consistency of measuring points by the same observer.
6. Nonetheless, directional asymmetry is independent of the hand function tests and does not predict either hand preference or hand efficiency.
7. Relationships between manual dexterity and handedness, hand dominance, and hand efficiency are individually expressed. The observed dexterity asymmetry may be associated, but is not necessarily equal to the asymmetry expressed in handedness, dominant hand performance, or dominant hand efficiency. These relationships can be further tested and undoubtedly displayed by a one-to-one mapping of the test results.
8. There may be substantial variations in dexterity asymmetry in groups with very similar levels of hand preference. However, finger dexterity testing is not well fitted to indicate hand efficiency by grip strength testing.
9. Hand type classifications demonstrate degrees of association with hand function tests, and can, therefore, be used to predict handedness and performance dominance. On the contrary, the classification of the hand types cannot be used to predict hand efficiency, dexterity dominance, or directional asymmetry.

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