USING A GONIOMETER FOR MOVEMENT ANALYSIS IN WATER - AN ALTERNATIVE TOOL

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INTRODUCTION

In the clinical setting, therapists have often been forced to develop new equipment and fabricate specialized tests to meet their needs in the evaluation and treatment of patients. These constructs are motivated by limitations of facilities and available equipment, as well as by a need to improve validity and reliability of methods used in clinical settings. To date, therapists have found that visual estimates are the only "means" of evaluation when using water therapy. The reliability of visual estimation is debatable on land (Youdas, Bogard, & Suman, 1993) and this problem is compounded in the water because of distortions.

Today, movement on land can be evaluated using both video and goniometer methods (Allard, Strokes, & Blanchi, 1995). In the clinical setting, Youdas, Bogard, & Suman (1993) suggested that the goniometer should be used when making repeated measurements for evaluation. Evaluation techniques are still being developed, validated, and standardized for the water medium. Currently, the most standard method of analyzing human movement in water is digitization. Data collections preceding digitization include video taping through an underwater dome port, flat port, or a pool side window as well as periscope systems or photographic registration. However, these methods require special facilities and/or equipment, which may limit their use in cliical settings. The purpose of this study was to examine the goniometer and to determine whether it may be a valid and reliable alternative to video analysis when evaluating in-water movement in clinical settings.

METHODOLOGY

For the purpose of this study, an underwater goniometer was developed. Prior to the actual data collection, three pilot studies were conducted to establish a standard water methodology for the goniometer. The reliability of an instrument (that is, the accuracy and repeatability of data), as in other forms of movement analysis, is fundamentally important to the success of an evaluation (Dainty & Norman, 1987). An initial study was conducted to determine if data at various angles of the goniometer were repeatable and linear. Four different testers measured six angles, on two separate occasions, three times each. An electrical goniometer attached to a measurement board marked with a circle and angles was used to note angles corresponding to measurements taken via a voltmeter. Variability of no more than one degree for any measurement was recorded, and averages were charted as shown in Figure 1. Simple Regression was run on the averages of all six measurements on a personal computer using SyStat. After linearity was established, a mechanical knee modeled after a 5'8" male was built from salt water wood. The lower portion of this joint was fixed and it consisted of a bolt with a locking device to limit motion to the upper portion. The angle could be moved dynamically or locked into place for static testing. For the second study, the goniometer was attached to this mechanical knee and a series of measurements at various angles were collected to establish the correct calibration techniques for the goniometer. Measurement techniques were tested for both land and water to determine the offset and scaling factors used. A final pilot study was done to determined the effect of temperature on the goniometer reading (measured as resistance). Since resistance varies linearly with temperature (Pallas-Areny & Webster, 1991) this experiment ascertained the parameters in the relationship: R = R ([LG1](1 + ((T - T( )), where R equals resistance and T equals temperature. Four angles were measured (180, 135, 90, and 45) for five conditions (water 11, 18, 25, and 30 degrees and air at 28 degrees Celsius).

Once correct methodology was established, a 2D analysis comparing video and goniometer data was completed. All data was collected via the mechanical knee using Peak software. The mechanical knee was calibrated so that 180 degrees (full extension) equaled zero. Data was collected at four relative angles: 0, 42, 90 and 136 degrees (where 42 represents 42 degrees of flexion from full extension). This collection was done so as to emulate a clinical setting with its inherent limitations. Utilizing established underwater methodology, a Sony HI-8 camera housed in an underwater dome port was used to collect video data (Griffin, Dufek, & Bates, 1991). The camera and lights, centered at the height of the joint, were placed perpendicular to a mechanical knee at a distance of 1.5 meters. The temperature of the water was 28 degrees Celsius and clarity was poor. Simultaneously, data was collected from a goniometer attached to the mechanical knee via the Peak System, and synchronized with video data. Pre and post measurements were compared to assure that reliability of the goniometer was maintained throughout the collection. After data was collected, Microsoft Powerpoint was used for graphing data for comparison.

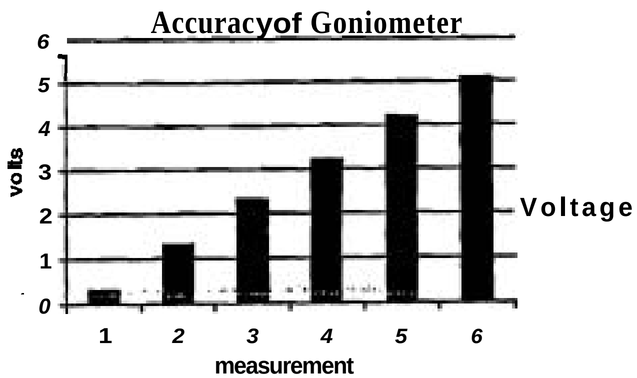

Figure 1. Six measurements ranged from 225 to 0 degrees. In 45 degree increments, while voltage ranged from 0.03 to 5.1 volts.

RESULTS

The results indicate that the gonoimeter is a reliable means to evaluate movement of a patient in the water. Figure 1 indicates that the goniometer was linear between 0-225 degrees with a correlation coefficient equal to 0.998 with a standard error of 1.71 degrees. In addition, the resistance of the goniometer was not affected in water temperatures ranging from 11-30 degrees Celsius. In cold water of 11 degrees Celsius, the goniometer maintained linearity, but the resistance was altered due to temperature. It was further noted that calibration of the goniometer must be done in the water environment in order to compare range of motion in different mediums - land and water. In the emulated clinical setting with limited space and poor visibility, Figure 2 shows that the goniometer produced data as reliable as that of video taping . Specific procedures are needed to maintain the reliability of the underwater goniometer. The goniometer must be checked for linearity and the scaling factor must be determined, both of which can be done on land. Acclimatization to the environment must be done prior to water use. Calibration of the goniometer should be done in the water using a mechanical knee or similar stationary device, not while attached to a subject. For clinical use, it is suggested that during calibration 180 degrees (full extension) be adjusted to equal zero. This method of calibration allows for noting flexion and extension of the joint. After calibration, the goniometer can be attached to the subject and used as an evaluation tool. The goniometer's reliability will be maintained for water temperatures ranging from 18-30 degrees Celsius. Therefore, if the therapist is working with several patients in various temperatures on a given day, there will be no need to calibrate for each patient. Furthermore, if calibration was done in the water, results suggest that land measurements can be compared to water measurements.

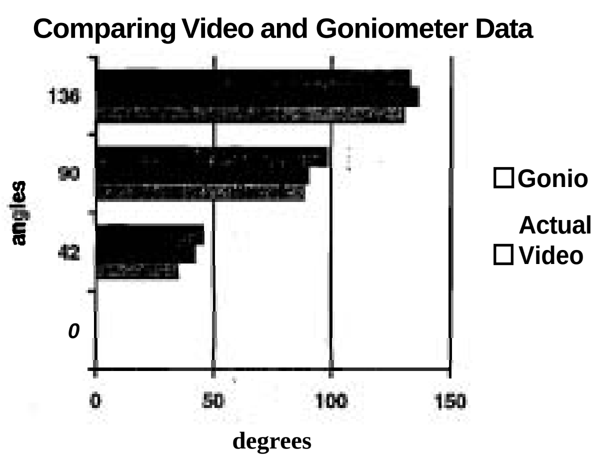

Figure 2. Results comparing gonbmeter and video data to actual data found that goniometer data was as accurate as video data

DISCUSSION

The clinical setting has many limitations. Regardless of these circumstances, the goniometer can be used as an alternative tool for evaluation and testing in water therapy. Nonetheless, caution should be noted. Although measurements were linear and repeatable, the goniometer and video data differed from the actual angles. These differences ranged among 0-7 and 0-5 degrees as the angle increased from 0-136 degrees for both goniometer and video respectively. Although video taping would perhaps be feasible in a swimming pool when evaluating numerous joints, video taping in the clinical setting is often inefficient. Video taping requires more room, more time to set up and analyze, is more costly, has limited frequency capability, and requires special equipment or windows in the pool. Furthermore, good visibility and correct lighting are critical for a successful analysis. Accuracy is somewhat sacrificed when video taping at short distances even when using the most expensive equipment. With correct methodology, the goniometer offers a quick and easy way to evaluate patients in the water. Error appears to be small, but the alignment and securing of the goniometer can be a likely place for error. Future research and product development are warranted. An evaluation of range of motion was successful using under water goniometry and is recommended as an evaluative tool. The goniometer requires less training, is easier to use, is quicker to setup, the data requires no digitization, is less expensive, requires little space, has immediate feedback, collection can be done at various frequencies, and visibility is not a factor. The results of this study indicate that a goniometer modified for water use would be a feasible and an effective alternative to video analyses when used in the evaluation and treatment of patients.

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