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A User-friendly Video Camera Based on Ergonomic Studies

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***Abstract* -- To design an ergonomically user-friendly video camera, electromyograms (EMGs) at six muscle locations were measured to find an optimal grip angle. Grip angle is an important factor in the usability of general consumer electronic products. The results indicated that vertically-gripped cameras, where the grip angle is large from the axis of the lens alignment, reduced muscular load. Particularly a grip angle from 105° to 135° produced little fatigue. In consideration of our results, we developed a compact and lightweight video camera with a grip angle of 105° based on ergonomic methodology.**

I. INTRODUCTION

Conventionally, ergonomic scientific research has looked into video camera usability and shooting styles, and suggested optimal shapes and shooting styles [1]. However, the recent reduction in size and weight of video cameras has allowed for revolutionary designs and shapes for video cameras. Furthermore the spread of LCD screens introduced various new shooting styles. Therefore, it has become necessary to study the optimal shooting style once again.

This time, we focused on the grip angle, one of the main factors in determining the shooting style. It has been also reported that the radial/ulnar deviation (wrist deviation toward a thumb or a little finger) is an important factor in achieving a suitable design for products with a hand grip [2]. In that respect, electromyograms (EMGs) and subjective evaluations were measured using several experimental models with different grip angles.

II. EXPERIMENT

A. Experimental camera

In order to examine the desirable shooting style from a muscular load point of view, experimental cameras with a different grip angles were fabricated (Fig. 1, 2).

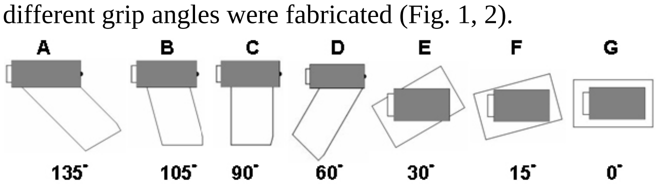

Fig. 1. Experimental models with different grip angles (Grey: Camera)

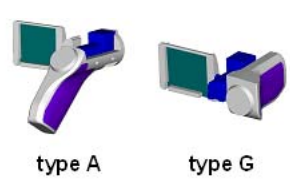

Fig. 2. Experimental models

Types A to D are vertically-gripped models and types E to G are horizontally-gripped models.

The grip shape of types A to G was the same. The grip angle is measured as the angle between the axis of the lens and the hand grip. To simulate real video camera shooting conditions, the experimental models were equipped with small cameras and LCD monitors. All experimental models weighed approximately 300g in consideration of the weight of currently available consumer video cameras.

B. Experimental method

The task given to the subjects was to track a spot of light controlled by a computer on a projector screen in the center of the camera LCD. The subjects stood at a constant location facing the screen while naturally holding the camera in the right hand. The center of the screen was set at a height of 138cm (average shoulder height of Japanese men).

C. Muscular load and subjective evaluation

EMGs at six muscle locations where physiological load was expected to be high during camera holding were measured. The six points are shown in Fig. 3. The muscles numbered from 1 to 4 in Fig. 3 contribute to bear the camera's weight, while the others (numbered 5 and 6) support the wrist joint with the camera in hand [3]. The muscular load was derived by RMS value of the EMG potential.

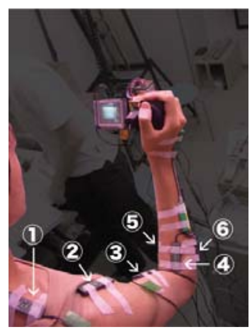

Fig. 3. Measured muscles (1: trapezius, 2: deltoid, 3: biceps brachii, 4: brachioradialis, 5: flexsor carpi ulnaris, 6: extensor digitorum)

Subjective evaluation included three items: "ease of grip", "stability" and "ease of track", as well as the determination of fatigable regions on the right side of the body. The evaluations were measured using the VAS (Visual Analog Scale) method while the fatigable regions were described in a special check sheet with circular markers.

Ten healthy male and female university students participated in this experiment as the subjects.

III. RESULTS AND DISCUSSION

A. Muscular load

The results of the muscular load during static and dynamic tracking were similar.

Fig. 4a, 4b and 4c show the relationship between the muscular load and the experimental cameras during the tracking tasks, respectively for the deltoid, the flexor carpi ulnaris and the extensor digirotum. A higher value indicates a higher muscular load.

For the deltoid and the extensor digitorum, Fig. 4a and 4c show lower muscular load for vertically-gripped cameras, compared to horizontally-gripped. The trapezius and the biceps brachii showed similar results. Significant differences, shown by the horizontal lines at the top of Fig. 4, were observed between vertically-gripped and horizontally-gripped cameras. The lower muscular load is likely due to the shooting style of vertically-gripped models. The elbow and the upper arm were supported by the body trunk, and the forearm was in a natural position, not in a supinated or pronated position (with the palm pointing up or down).

For the extensor digitorum (Fig. 4c), which extends the four fingers and stabilizes the wrist joint, muscular load was particularly high when using the horizontally-gripped cameras. The reason was that in the shooting style of horizontally-gripped models, the muscle needed to support a bigger moment to the palmar side and required a larger activation to hold the camera, resulting in an unnatural wrist posture.

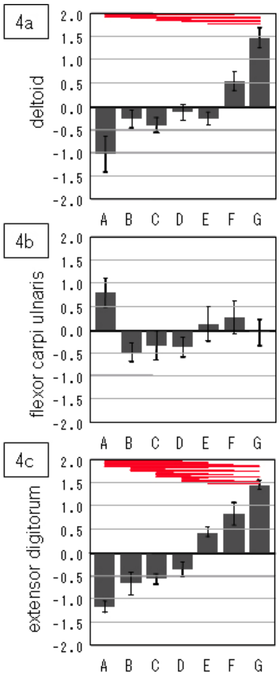

Fig. 4. Results of the muscular load during the tracking task ($p < 0.05$) (a: deltoid, b: flexor carpi ulnaris, c: extensor digitorum)

For the flexor carpi ulnaris (Fig. 4b), only the type A camera showed higher muscular load among the vertically-gripped cameras. However its difference was not significant. It is most likely that the larger ulnar deviation (wrist deviation toward a little finger) caused the higher muscular load as the grip angle is larger.

B. Subjective evaluation

Fig. 5 shows the relationship between the subjective evaluation result and the experimental models. Each graph represents the three evaluated categories. A higher value indicates a better evaluation.

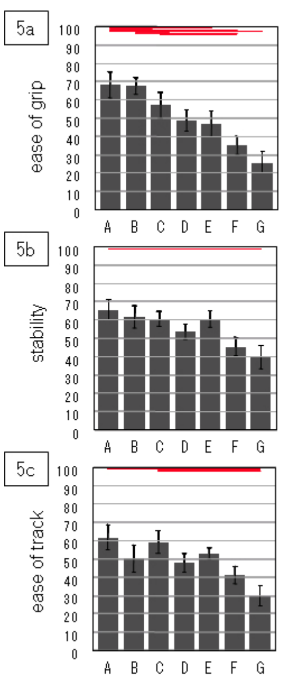

Fig. 5. Results of the subjective evaluation of the three categories ($p < 0.05$) (a: ease of grip, b: stability, c: ease of track)

As the grip angle increases, the evaluation scores tend to be higher. Significant differences, shown by the horizontal lines at the top of Fig. 5, were observed between types A and G in regards to all of the three evaluated categories.

Fig. 6 indicates the result of the subjective "fatigable regions" evaluation. The subjects feel more fatigue at the regions indicated by darker colors. The results showed that many subjects felt fatigue in their shoulder, upper and lower arms when using the horizontally-gripped models (ex. type G camera). More than half of the subjects suffered from fatigue in their shoulders and upper arms. Vertically-gripped models (ex. type B camera) showed a tendency for the subjects to feel fatigue in their forearm. Furthermore only the type A camera showed a fatigable region in the subject's index finger as indicated by a star in Fig. 6.

The results of our experiment show: (1) cameras with a larger grip angle show lower muscular load and receive a higher score for the subjective evaluation, (2) cameras with a grip angle of more than 105° causes a higher muscular load with regard to the flexor carpi ulnaris because of the large wrist deviation. From these results, it can be concluded that an optimal grip angle for the shooting style is from 105 to 135°.

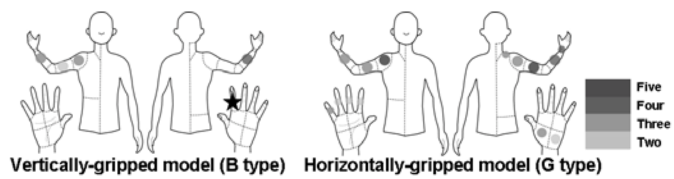

Fig. 6. Fatigable regions colored by the number of subjects feeling fatigue at those regions during the experiment (Left: Front of the subject and palm, Right: Back of the subject and the back of the hand)

IV. CONCLUSION

In our study, grip angle was examined to determine the most comfortable shooting style from a muscular load point of view. Considering the results of our experiments, one of the best grip angles for a consumer video camera seems to be around 105° due to size and weight constraints. Based on this consideration, we developed an ergonomically user-friendly video camera with a compact and lightweight body having a grip angle of 105° (Fig. 7).

Fig. 7. Ultra Compact Full HD Video Camera

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