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Infant life jacket donning trials using children and their parents: Comparison to the Canadian standard

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ABSTRACT

Introduction: Canadian drowning rates for children are high and an increased demand for child flotation devices with novel designs is expected. This experiment was conducted to: 1) record the donning performance of life jackets on children/infants using the methods outlined in the Canadian standard; and 2) to compare the donning performance results to the previously reported results using a soft manikin.
Method: Four different child life jackets were procured for evaluation. Adults and their children were recruited from the Halifax region to participate.
Results: Fifty-five participants completed at least one donning trial with one of the four life jackets. Findings were in general agreement with the previous manikin study. Manikin testing showed consistent results with human testing for life jackets that are both well designed or poorly designed, but were not consistent for "mediocre" life jackets. Each sub-task added 10 s to the donning process. Incorrect donning was yet again caused by clips and ties that were not colour and/or size coded.
Conclusions & recommendations: A manikin may be offered as an alternative for a human in the donning tests. For "mediocre" life jackets that fail the manikin test, a human test can always be used to clarify the situation.

1. Introduction

Between 1991 and 2000, the Canadian Red Cross found drowning to be the fourth most common cause of unintentional death in Canada; it was only surpassed by highway accidents, falls and poisoning, respectively (Canadian Red Cross, 2003). The majority of actual drowning deaths (n = 4671) and near drowning deaths (n = 3289) occurred during recreational or sporting activities, while the two most at risk populations in rank order were adult males, followed by youth and infants/children between the ages of 1–4 years. Although the majority of child drowning deaths occurred in pools and bathtubs, adult/infant recreational activities in open water seem to be occurring more frequently. Thus, the Transport Canada, Marine Safety Branch is anticipating that there will be a higher demand for child flotation devices and have noticed an increase in requests for approval of flotation devices with novel designs (Murray, 2008).

The majority of drowning deaths in Canada are believed to be preventable by wearing flotation devices when in or around water, as supported by Brooks (Brooks, 1995). In Europe and Canada, flotation devices are commonly referred to as life jackets, a device that "provides face up in-water support to the user regardless of the physical condition of the user" (International Standards Organization, 2006). All flotation devices evaluated in this study are recognized by regulating authorities as life jackets and will be referred to as such. In addition, for simplicity all infant/child life jackets will be called children's life jackets.

In 1991, Funkhouser and Fairlie (Funkhouser and Fairlie, 1991) evaluated 4 children's life jackets under ideal conditions and found that life jackets with a complex design increased the time to don. In 2001, this finding was further explored by Coleshaw et al. (Coleshaw et al., 2001), who found that fathers could only don 3 out of 5 children's life jackets on their child in less than or equal to 1-min. The authors stated that the primary cause of the increased donning time was due to the complicated design of the crotch strap.

In 2011, MacDonald et al. (MacDonald et al., 2011) extended this work and evaluated 8 children's life jackets. Due to the possibility that the behaviour of a child might confound the results of the donning procedure, a deliberate decision was made to have the

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parents/guardians (adults) don the life jacket on a soft manikin. It was noted that as the number of sub-tasks required to don the life jacket increased, donning time increased by an average 10 s per task and donning accuracy (correct donning) decreased. These findings were in agreement with Funkhouser and Fairlie in 1991 (Funkhouser and Fairlie, 1991) and Coleshaw et al., in 2001 (Coleshaw et al., 2001). It was also found that a learning effect existed when adults attempted to don more than one life jacket on to a soft infant manikin in the same session (MacDonald et al., 2011). Regardless of life jacket type, there was a significant reduction in donning time between the first and second attempt at donning, but not between the second and all subsequent attempts. This finding was consistent with that of Funkhouser and Fairlie (Funkhouser and Fairlie, 1991), who found that although the effect of order did not yield a significant difference, there was an average 11.6-s drop in donning time between the first and second attempt. This finding has consequences for test houses that tend to use experienced people to act as test subjects. If the jacket is intended for use of an occasional or novice user then using experienced test subjects will significantly underestimate the actual donning time of a less experienced user. The MacDonald et al. (MacDonald et al., 2011) study clearly showed that if this practice continues, then some poorly designed life jackets may be incorrectly approved.

Based on the requirements outlined in Section 6.9, 6.10 and 6.11 of the Canadian life jacket standard CAN/CGSB-65.7-2007 (Canadian General Standards Board, 2007), the main purpose of this study was to record the donning performance of four representative life jackets on children using the methods outlined in the Canadian standard. The second purpose was to compare the donning performance results on children to the previously reported results using a soft manikin (MacDonald et al., 2011), and use adults and their children as subjects in the donning procedure. For a child life jacket to receive certification it must meet the following donning performance criteria (in water performance will be reported in a separate paper):

- Donning time: The time in seconds required to complete a donning in $\leq$1-min;
- Donning accuracy: The measured accuracy of completing a donning 100% correctly by $\geq$80% of participants on their first attempt, and 100% correctly by 100% of participants on their second attempt;

The experiment was approved by the Dalhousie University Ethics Committee and the work was conducted under a grant from the Transport Canada, Marine Safety Branch.

2. Material & methods

2.1. Procurement of representative child life jackets

Eight children's life jackets were evaluated in the original experiment (MacDonald et al., 2011) using a soft manikin. Due to the learning effect that was noted in the original study (MacDonald et al., 2011), each adult in this study was only required to don one life jacket on their child. Principally, due to the difficulty of recruiting adults and children and allowing only one donning per subject, the total number of life jackets chosen was reduced to four of the original eight. Each life jacket was inherently different from the others with respect to the performance type, number of sub-tasks and the location of ties, zips and clips. By the sheer fact of these differences, of the 4 life jackets chosen, both the simplest and best performing life jacket in the previous study, and the most complex and worst performing life jacket ended up being included. Table 1 presents a breakdown of the total number of sub-tasks required to don each life jacket correctly, as well as how the total number of sub-tasks is divided, by type of sub-task. For example, life jacket A requires 5 total sub-tasks to be completed for a correct donning, and these 5 sub-tasks include: (1) placing the child in the life jacket; (2) zipping a zipper; (3) clipping one clip; (4) clipping a second clip; and (5) adjusting all straps.

Life jackets B, C & D were procured from outside of Canada and were therefore not approved for use in the Canadian market place; while life jacket A had been approved under the recently rescinded CGSB/CAN-65.7-M88 standard (Canadian General Standards Board, 1988). Until now, Canada has had a very conservative policy on child life jacket design; and so, there are very few design options for customers wishing to purchase “approved” life jackets. This was one of the benefits for conducting this experiment using life jackets which were not approved in Canada; so that we could possibly identify other novel child life jacket designs which may have the potential for future approval in Canada, under the new standard.

2.2. Establishment of the donning procedure

To evaluate donning accuracy, an ordered list of the critical tasks necessary to don each life jacket was created by a group of marine survival instructors, who had a combined knowledge of over 60 years of experience in sea survival training. The list was formulated to specify the optimal order/sequence in which the sub-tasks should be completed. Sufficient flexibility was permitted to allow an alteration in task sequences without directly leading to a failure of the donning procedure. This list formulated the basis of the measurement of donning accuracy and an example is presented in Table 2.

This critical list of sub-tasks was used to compare the order in which each participant completed the donning task. If a participant elected to complete a life jacket donning in a different sequence than the one identified by the experts, it was not necessarily deemed a failure as long as all critical sub-tasks were completed at the end of the process. For instance, to correctly don life jacket B, the zipper should be zipped up before connecting the chest clip. However, it was possible to connect the chest clip buckle before zipping the zipper, so as long as both sub-tasks were completed at the end of the donning process; it was considered an accurate donning.

2.3. Choice of participants and group allocation

Participants were chosen using a sample of convenience from Dalhousie University and the surrounding Halifax, Nova Scotia, Canada region. Adults and their children were allocated to life jacket groups based on: i) their experience in and around open water; and ii) their experience with donning life jackets. This information was gathered via questionnaire administered to each adult prior to testing. Based on the answers to the questionnaire, adults were stratified by experience and then randomly assigned into life jacket groups A, B, C or D. Once allocated, it was then determined if the adult would allow their child to attempt a self-donning without the adult's assistance. If the adult allowed this donning procedure to occur, then the child was given the first opportunity to attempt a self-donning. The success or failure of the child's self-donning was noted, after which the adult started the donning procedure again from the beginning. The donning trial performed by the child was not viewed by the adult although the adult was present in the room.

2.4. Donning instructions

Section 6.9 of the Canadian standard states that prior to the