Naval Submarine Medical Research Laboratory

NSMRL Report No. 1237 18 August 2004

EXERCISE ABOARD ATTACK SUBMARINES: RATIONALE AND NEW OPTIONS

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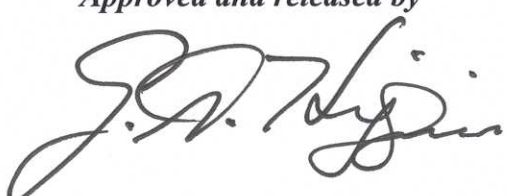
Approved and released by



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ABSTRACT

Substantial scientific evidence supports the potential benefits of exercise for submariners: regular exercise improves many human functions that directly apply to submarine operations. These benefits include improved alertness, cognitive function, immune function, weight control, strength and fitness (for damage control, etc.), mood state, responses to stress, sleep quality, and quality of life. However, most submariners do not exercise during deployment for a variety of reasons, including lack of space, time limitations, equipment limitations, lack of entertainment or recreational value associated with exercise, low oxygen levels, high carbon dioxide levels, and hygiene challenges. A need exists to significantly improve participation in and effectiveness of exercise for submariners, in part by increasing the variety and effectiveness of available exercise options, and also by making exercise on submarines more enjoyable. Submarine Fitness Coordinators report that equipment limitations constitute one of the most important and addressable problems. Fitness Coordinators and the authors identified the following desirable exercise device characteristics: effective, durable, safe, quiet, small, fun, easy and convenient to use, and not unduly expensive. Several existing and emerging exercise technologies exist to improve upon those currently in use aboard submarines. Integration of virtual environments with exercise hardware represents one of the most interesting and promising emerging technologies. Improving exercise capabilities for submariners also augments the means and ability for special operations units deployed aboard submarines to maintain fitness.

Some alternative exercise options to consider

Submarine Fitness Coordinators report that equipment limitations constitute one of the most important and addressable problems, and correction of equipment limitations may help alleviate some of the non-equipment limitations. For example, crewmembers may feel more encouraged to exercise if it uses their time efficiently, is enjoyable, and/or more directly addresses their fitness desires (for example, aerobic *and* strength training).

Currently popular exercise devices such as upright cycle ergometers, steppers, and the Versaclimber should continue to be supported. Importantly, a treadmill (Quinton Clubtrack 510) has been approved for use aboard attack submarines, so no need exists to revisit this conclusion. However, as Vickers and co-workers noted in 1982 (25), "providing exercise facilities does not ensure their use" on submarines.

Attack submarine Fitness Coordinators and the investigator team identified these desirable exercise device characteristics:

- Effective, time-efficient maintenance of fitness
- Durable enough to withstand high use with very low or no maintenance
- Safe/non-injurious, including during ship movement
- Quiet, so as not to disturb submarine operations or sleeping crew
- Small enough to fit through hatches and passageways, to fit in areas for exercise gear, and to avoid impeding access/operations
- Fun, to allow crew recreation, enhance quality of life, and encourage use
- Easy and convenient to use; minimal time spent with device set-up ("walk up, work out, walk away")
- Cost-effective: expense of the device is reasonable and not prohibitive.

Some exercise options to consider include the following, and other unexplored options probably also exist.

Weight vest worn during running in place, calisthenics, and stepping

This is a heavy duty nylon vest constructed with numerous pockets on the front and back into which the exerciser places small weights. The user may add between 1 and 40 kg (~2-90 lb) of weight to the vest. Adjustable straps secure the vest around the exerciser's chest. The user may run in place, perform stepping exercise (on a small locker, for example), and perform multiple calisthenics while wearing the weight vest (for example, see one possible program at weightvest.com/chart.html). In addition to use by submariners, training with a weight vest could be particularly valuable for SEALS on submarines in transit to a mission, in part as a means of simulating the loaded backpack they might carry during an operation. Commercially available units cost ~$100-200.

Respiratory muscle training (RMT)

Respiratory muscle training (RMT) is a relatively recent training technique that improves submaximal cycling exercise endurance up to 50% (4-6). RMT involves breathing at a high

ventilation volume (hyperventilation) against minimal resistance with the remainder of the body at rest. Hypocapnia is avoided by partial rebreathing from a bag. The RMT system controls the degree of rebreathing and therefore also avoids hypercapnia. The improvement in endurance capacity with RMT is associated with lower blood lactate levels during exercise as well as a 300% increase in breathing endurance (i. e. ability to maintain 75% of maximal voluntary ventilation). Researchers at the Center for Research and Education in Special Environments at the State University of New York at Buffalo are currently evaluating RMT for use by divers and Special Forces personnel. Preliminary results suggest that RMT improves submaximal exercise endurance at depth (26) and altitude (15) as well as running endurance at normal ambient pressures (Lundgren, personal communication).

The advantage of RMT over traditional aerobic training methods is that RMT can be performed in a limited space with minimal equipment by multiple individuals at the same time. Our intent of RMT for submarine use is not to recommend it as a general and full substitute for traditional aerobic training, but to suggest its utility for maintaining aerobic endurance when traditional methods of aerobic training are not available or practical during deployment. This may be the case aboard fast attack submarines during operations where Special Forces personnel and equipment utilize the space normally assigned for traditional exercise equipment. RMT may also serve as an adjunct to traditional training methods. One commercially available RMT unit costs ~$1200 (spirotiger.it).

Exercise in virtual environments

Obviously, virtual environment technology is not an exercise technology per se, but its use may improve submariner participation in exercise by making exercise fun. For submariners and others, motivation to exercise suffers when exercise offers no entertainment or recreation. If exercise is made fun or associated with fun activities, then motivation to exercise is "built in". One example of commercially available exercise virtual environment technology appears at fitcentric.com (software $100; virtual courses $10-25; hardware (hundreds?)). Virtual environment hardware and software may be integrated with a variety of different aerobic exercise devices (treadmills, cycles, etc.).

Exercise on submarines does not currently offer much if any entertainment or recreational value. Also, submarines lack many other common sources of entertainment and recreation, which adds to the stress of submarine life. Submariners commonly listen to music on personal stereos during exercise, but exercise in a virtual environment or watching a video during exercise would probably be significantly more enjoyable. Fitness clubs commonly place TVs in front of exercise equipment.

In submarines, openly visible virtual environment displays or video could distract other crewmembers working nearby, hence the suggestion for personal, head-mounted display for accompanying exercise on submarines. Another concern is attentiveness to alarms: as with personal stereos, submariners using head-mounted displays during exercise would need to keep the sound volume low enough to hear alarms.

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14. Abstract (cont)

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