ASSESSMENT OF SOLDIERS´ PHYSICAL PERFORMANCE AND FITNESS: A NEW APPROACH COMPRISING VALID TESTING, LINKED DATA AND MODERN QUALITY MANAGEMENT

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INTRODUCTION

Throughout the last decades numerous sport-motoric tests have been used in the military to assess soldiers´ physical performance and fitness (1, 3, 5, 7) . However; many of these sport-motoric tests fail to meet the quality standards of classic test theory (objectivity, reliability, validity). E.g., even small changes in the execution of sit-ups or chin-ups may result in vast differences in efficiency due to the inherent degrees of freedom in the test. Thus such performance tests have to be considered with some reservations (1, 4, 11, 15).

Acknowledging these shortcomings, the German Bundeswehr identified the need for new means of assessing physical fitness and performance in military personnel (2). A research project was initiated with the aim to develop a new system which would be able to assess basic physical capabilities irrespective of age or gender, at regular intervals, in every soldier throughout the complete working career (4). Strict adherence to quality criteria (objectivity, reliability, validity) was of paramount importance for the assessment of strength, endurance and coordination. For deployment throughout the German Bundeswehr, the individual tests needed to be suitable for a large, inhomogeneous population, for any age and for both genders (5-9). Data acquisition and analysis had to meet all prerequisites and requirements for modern quality management, including scientific research for continuous evaluation and adaptation.

For Bundeswehr-wide deployment the test-battery had to feature additional properties (4): It had to be easy to administer, largely independent of infrastructure and special tools or materials. Additionally, trained personnel should not be necessary for test implementation.

METHODS

In order to meet the criteria outlined above, three sport-motoric tests reflecting strength, speed/ coordination and endurance were designed and evaluated. Design and selection were based on extensive research (4, 6, 8, 12-14). Further criteria for design and selection were to limit (i) degrees of freedom (ii) the amount of time for administration. All tests use simple timing with a stopwatch as basic means of measurement.

- **Strength test: Hanging off a horizontal bar in "chin-up" position**

Participants are supported in the "chin-up" position until the test begins. With the starting signal the support is removed and participants hang off the bar in the initial position until the position cannot be upheld any longer. The test ends when the chin can no longer be kept above the bar. Time is taken in seconds (Fig. 1).

Upper body strength is an important factor in lifting, load carrying or climbing (4, 9, 10). With a defined starting and cut-off position, and its largely isometric demands the test is designed to limit degrees of freedom as much as possible.

Fig. 1: "Chin-up" position

- **Speed/Coordination: 11x10-m shuttle run (with changes in body position)**

Short sprints combined with changes in body position often occur in the military setting, especially in MOUT scenarios. They require a unique mix of speed, and coordination. The shuttle sprint was designed to reproduce these demands under controlled conditions and limiting the degrees of freedom as much as possible (4, 15).

Participants of the 11 x 10-m begin lying face-down on a mat. A mark is placed in 10-m distance. With the starting signal the participants have to jump up, run around the mark and back to the mat, lie down again and start anew until 11 rounds have been completed. The time to completion is measured in seconds (Fig. 2).

Fig. 2: 11 x 10-m shuttle run with changes in body position from prone to upright

- **Endurance test: 1000-m run on the track**

Endurance has traditionally been assessed with running over longer distances. Reducing the distance to 1000-m also reduces the amount of time for test administration while retaining test-sensitivity for measuring endurance (4). The test component to determine endurance consists in a 1000m run on the track. The time is measured in seconds (Fig. 3).

Fig. 3: 1000-m run on the track

Information about age, gender and the situation at the workplace are recorded in a standardized oral interview.

➢ Rating System

In addition to the testing procedures, a rating system to provide fair and comparable ratings for men, women and elderly persons was developed (4, 8, 14). A baseline for minimum performance was defined for every test. For above-baseline performances the time in seconds is measured in every discipline and converted into a basic numeric. A bonus can be obtained depending on age and gender in each discipline (Tab. 1 and Tab. 2). The bonus is then added to the initial score in each discipline, results are then converted into school grades (1-4). One overall result is derived by combining the three grades for each discipline. This procedure ensures that the test system is neutral for age and gender at baseline and comparable for age and gender above.

Tab. 1: Bonus depending on age - in every discipline the following bonus is given for males and females for every year over 35 years

per year	+ 0,5 %

Tab. 2: Bonus depending on gender – in every discipline the following bonus is given for females at every age

11 x 10-m dash with changes in direction and body position	+ 15 %
Holding on a horizontal bar in chin-up position	+ 40 %
1000-m run on the track	+ 15 %

➢ - Data processing and-storage

To account for the postulated requirements with respect to modern quality management, including scientific research for continuous evaluation and adaptation, a modular database system was designed implemented (10). Interview results and all individual test results are aliased; time tagged and stored allowing for cross-sectional as well as longitudinal analyses.

PRELIMINARY RESULTS

For evaluation purposes, data were obtained from over 6000 healthy participants. All participants were informed of aim and scope of the testing and gave their written consent.

Figs. 4, 5 and 6 show sensitivity of the newly developed or adapted tests. Results are spread enough to allow for differentiation between individuals. All tests are also able to detect differences between genders.

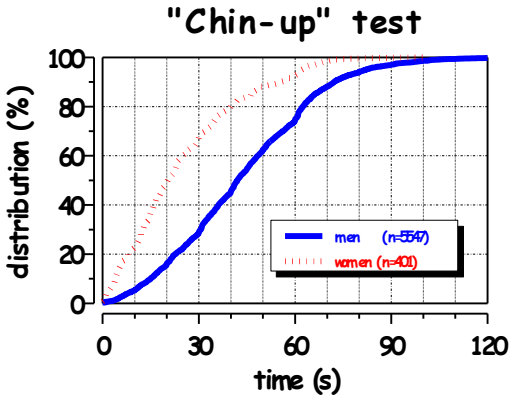

Fig. 4: Hanging off a horizontal bar in “chin-up” position. (Distribution of holding times over all given as cumulative percentage)

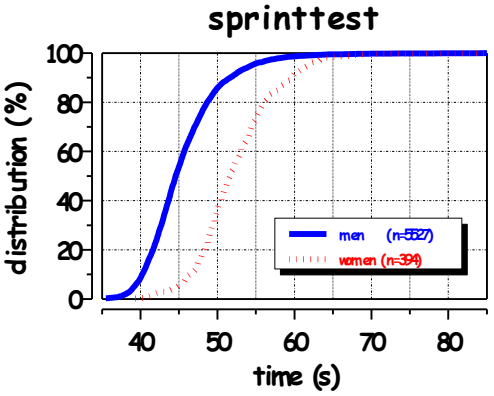

Fig. 5: 11 x 10-m shuttle run with changes in posture: Time needed to complete 11 turns. (Distribution of sprint times given as cumulative percentage)

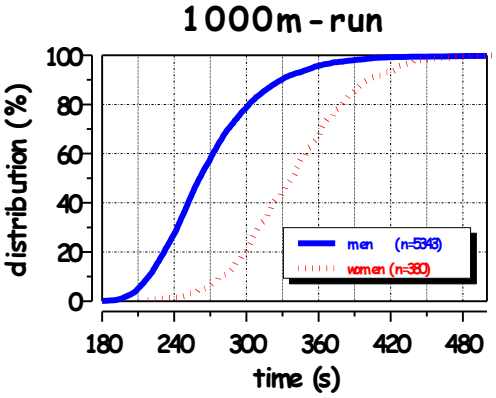

Fig. 6: Running times of 1000-m run on the track. (Distribution of 1000m-times given as cumulative percentage)

CONCLUSIONS

At this stage, testing procedures consist of

(i) recording the physical capability with three simple tests, complemented with basic information about the individual. All tests are easy to administer and require neither specialized infrastructure nor specially trained personnel for administration.
(ii) Using the derived baseline as cut-off criteria as well as using the rating system to modify scores. All scores and ratings are transparent and balanced for age and gender.
(iii) Data acquisition and analysis using a newly developed, modular IT-framework and a relational database to allow for modern quality management and scientific research and for continuous evaluation and adaptation of methods.

Single procedures as well as the complete system have undergone extensive testing and evaluation with more than 6.000 participants. Special focus was put on practicability, correct definition of baseline values, sensibility of the rating system, usability of the quality management system and acceptance in the military personnel The use of a relational database system allows for combined datasets, connecting interview data with the results from all testing procedures, thus providing a comprehensive overview over performance capabilities down to the individual level. It provides further analysis potentialities and provides the necessary and reliable basis for the desired open and amendable system. New features can be implemented easily while data integrity and consistency is retained. As a next step a lifestyle-specific questionnaire and a defined set of anthropometric measurements may be a good addition to the datasets. The whole system, combining specific well-founded tests with modern information technology ensures procedures that meet the demands of both the military setting and a modern quality management.

With the modification of procedures and rating systems and the ability to use 6000 datasets as base cohort, the test will be implemented as standard Bundeswehr procedure in 2010.

REFERENCES

1. Bilzon JL, Allsopp AJ, Tipton MJ: Assessment of physical fitness for occupations encompassing load-carriage tasks. Occup Med 51; 357-361 (2001)
2. Bundesministerium der Verteidigung, Generalinspekteur: Weisung zur Ausbildung und zum Erhalt der Individuellen Grundfertigkeiten. Bonn (2006)
3. Eisinger GCh, Wittels P, Enne R, Zeilinger M, Rausch W, Hölzl T, Dorner G, Bachl N: Evidenced-base job analysis and methodology to determine physical requirements of special military occupations. NATO Research and Technology Organisation RTO-TR-HFM-080: Final Report on Optimizing Operational Physical Fitness (Chapter 6). RTO ISBN 978-92-837-0052-4 (2009)
4. Essfeld D, Rüther T, Wunderlich M, Sievert A: Entwicklung einsatznaher Leistungstests und Prüfverfahren. Forschungsbericht aus der Wehrmedizin M/SAB1/3/A011 (2006)
5. Leyk D: Effects of gender on operational physical performance. NATO Research and Technology Organisation RTO-TR-HFM-080: Final Report on Optimizing Operational Physical Fitness (Chapter 7.1). RTO ISBN 978-92-837-0052-4 (2009)
6. Leyk D, Erley O, Gorges W, Ridder D, Wunderlich M, Rüther T, Sievert A, Essfeld D, Baum K: Körperliche Leistungsfähigkeit und Trainierbarkeit im mittleren und höheren Lebensalter. Wehrmed Mschr 51; 148-152 (2007)
7. Leyk D, Erley O, Bilzon J: Effects of age on operational physical performance. NATO Research and Technology Organisation RTO-TR-HFM-080: Final Report on Optimizing Operational Physical Fitness (Chapter 7.2). RTO ISBN 978-92-837-0052-4 (2009)
8. Leyk D, Erley O, Ridder D, Leurs M, Rüther T, Wunderlich M, Sievert A, Baum K, Essfeld D: Age related changes in marathon and half-marathon performances. Int J Sports Med 28, 513-517 (2007)
9. Leyk D, Gorges W, Ridder D, Wunderlich M, Rüther T, Sievert A, Essfeld D: Hand-grip forces of young men, women and highly trained female athletes. Eur J Appl Physiol 99: 415-421 (2007)
10. Leyk D, Jürgens H: Combined physiological and anthropometrical databases as ergonomic tools. J Physiol Anthropol 25; 363-369 (2006)
11. Leyk D, Rohde U, Gorges W, Ridder D, Wunderlich M, Dinklage C, Sievert A, Rüther T, Essfeld D: Physical performance, body weight and BMI of young adults in Germany 2000 – 2004: Results of the Physical-Fitness-Test Study. Int J Sports Med 8: 642-647 (2006)
12. Leyk D, Rüther T, Wunderlich M, Heiss A, Ridder D, Küchmeister G, Löllgen H: Sporting activity, prevalence of overweight, and risk factors – cross-sectional study of more than 12500 participants aged 16 to 25 years. Dtsch Arztbl Int: 105: 793-800 (2008)
13. Leyk D, Rüther T, Wunderlich M, Sievert A, Rohde U, Piekarski C, Löllgen H Leistungsfähigkeit und Alter: Der Marathon als leistungsphysiologisches und prä-ventivmedizinisches Untersuchungsmodell (PACE-Studie). In Kirch W, Middeke M, Rychlik R: 3. Nationaler Präventionskongress. Thieme-Verlag, in press (2009)
14. Leyk D, Rüther T, Wunderlich M, Sievert A, Essfeld D, Erley O, Gorges W, Ridder D, Piekarski C, Erren TC: Performance, training and lifestyle parameters of marathon runners aged 20 to 80 years: Results of the PACE-Study. IJSM 30: 360-365 (2009)
15. Rohde U, Erley O, Rüther T, Wunderlich M, Leyk D: Leistungsanforderungen bei typischen Einsatzbelastungen. Wehrmed Mschr 51; 138-142 (2007)