Sports, exercise and health science

Overall grade boundaries

Standard level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 15	16 - 30	31 - 42	43 - 53	54 - 64	65 - 75	76 - 100

Standard level internal assessment

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 8	9 - 16	17 - 22	23 - 27	28 - 33	34 - 38	39 - 48

The range and suitability of the work submitted

The quality of the candidates' IA work continues to improve and teachers should be congratulated for their efforts. Teachers are also to be commended for acting on the 2016 subject report, and for taking a lot of time and trouble to prepare their Internal Assessment sample. The variety of investigations, duration and coverage of the practical programme was varied and was excellent in some schools. Once again, there was a range of hands-on activity in most core topics along with a sound use of ICT by some candidates. Most schools used appropriate investigations of a sound standard.

The majority of candidates were allowed to conduct their own investigations with teacher prompt, however, insufficient latitude with designs in some schools' results in a whole class attempting the same or similar investigation. Teachers rarely commented on the unsuitability of designs that are already covered completely in readily available literature such as the effect of running intensity on heart rate levels and often awarding full marks. Many candidates produced outstanding reports with very thorough background research and reference to ethical issues both in their design and again in their conclusion. Teachers do need to highlight to candidates that literature sources provide valuable background information in determining the initial research question and in the discussion of the results. Some teachers continue to provide too much information and as a result candidates cannot be awarded a complete for their design.

Candidates sometimes miss quite obvious conventional points (e.g. indicating uncertainties in their data) as well as limiting their processing to the calculation of a mean. Those teachers who do not identify these omissions tend to mark over generously. Some moderators are surprised to find that teachers point out significant errors to their candidates yet still give full marks.

Some schools expect their candidates to use a pro-forma to obtain signed consent from participants in experiments. This is essential ethical practice but it was too rare and moderators commented on the absence of signed consent in investigations involving human subjects. Candidates should also be reminded to report briefly on any ethical issues that arise during their investigations e.g. confidentiality of participants. Using fellow candidates for investigations into the effect of exercise on heart rate or effect of caffeine supplementation on performance can be considered unsafe if the health status of the candidates is not determined first. There is a continued increase in the number of designs with caffeine supplementation (e.g. oral pills) being used as the independent variable and this being deemed to be at 'safe' levels by the candidate administering them. This is problematic at best, and could lead to unintended side effects in candidates in practical activities, based on the fact that the candidate is not a medical professional, and in turn not able to accurately evaluate candidates and medicine.

Some candidates need more freedom to choose their own area of investigation with the opportunity to fail early on and prevent gross errors in final submissions. The moderators continue to be concerned when the only marks appearing on the 4/PSOWSEHS form were the two marks required for internal assessment. There was often no indication that candidates were marked a number of times using the criteria and provided with opportunities to practice the skills required. One wonders how these candidates receive the necessary feedback to improve their performance.

Candidate performance against each criterion

There appears to be a lot of variability in how practicals are approached and marked, suggesting more training is needed to bring better understanding and consistency among teachers. In some schools, teachers applied the criteria rigorously and clearly, and moderators were able to make relatively small adjustments to the marks. In schools where the descriptors of the different aspects were ignored, moderation may have reduced the marks quite severely. Teachers who included the "complete", "partial" and "not at all" breakdown of their marks provided helpful information to the moderators. When this was combined with comments and feedback to candidates it was very clear how teachers had awarded marks. It was a lot easier for a moderator to support a teacher's marks when there were clear, readable notes accompanying the sample. No or limited written teacher comments on reports for candidates also makes one wonder how these candidates receive the necessary feedback to improve their performance.

Design (D)

The quality and expectations of candidates from different regions around the world varies widely, and it is hoped that as teachers gain experience and understanding, regional variations

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will reduce. Some teachers are setting general themes with little scope for different investigations. The result is that the whole class selects the same variables and investigates the same system. This approach will have a very negative impact on the new Individual Investigation which will be examined in May 2018. Commonly, candidates do not show curiosity and present undemanding Research Questions for which the outcome is well defined in the syllabus or self-evident; alternatively, the report describes a 'commonplace' school investigation with a procedure that has not been adapted or extended in any way. Research questions need to be focused; a research question that lacks focus will have an impact throughout the whole investigation. Standard protocols will, no doubt, be used by the candidates when they design their investigations. We are not expecting them to re-invent the wheel. However, these standard protocols must be duly referenced and significantly modified or applied to the candidate's own investigation. Teachers who are encouraging candidates to be creative with their own designs and who in turn provided insightful pieces of work are to be commended, even if some did lead to trivial results.

Most designs submitted followed the scientific method of conducting research; however, some candidates (and teachers) continue to have difficulty identifying independent, dependent, control and confounding variables. Candidates must be taught to always include measurements when outlining the dependent (measure) variable e.g. cm and check their independent (change) variable. Most candidates were very well trained in providing a list of the controlled variables and discussing how the impact of confounding variables could be reduced. One of the weaker areas is in the form of the methodology; it must be clear how the dependent, independent and control variables have been appropriately considered and include enough procedural detail. To gain a complete for Design Aspect 2 the method needs to be detailed, ideally numbered and followable with no previous knowledge (e.g. protocol, equipment, sample, numerical amounts, units of measurement). The range of values of the independent variables and number of repeats (ideally have 3-5 repeats for each variable) were not always sufficient to establish trends or permit statistical analysis. Candidates must ensure that they have an appropriate sample size for the statistical analysis to be valid. The sample size will vary depending on what is being measured and the intended type of analysis. Consent forms were often used; however, many candidates did not make reference to this in their method and as such there was no option for subjects to withdraw.

Some schools were using established design prompts; in others, the prompts were not appropriate because the teacher gave the candidate the equipment, relevant formula and the independent variable. Teachers should avoid setting designs that are already covered completely in readily available literature. The research question/focused problem is different to the teacher prompt and candidates should include the dependent (you measure) and the independent (you change) variables.

It is good practice for candidates to follow through their own designs. Some schools seem to have their candidates design an investigation that remains theoretical. The result is often an unrealistic investigation. Even when a teacher does decide to follow through a candidate designed investigation the result may be an unrealistic investigation. An example that keeps reappearing is measuring the effect of music genre on heart beat rates. This is almost impossible to control and candidates ought to be counselled against it from the outset. They

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might be advised to use a metronome instead (they should be left to work out for themselves that the volume and the frequency can be controlled).

Data collection and processing (DCP)

A problem relayed by moderators was that some investigations did not generate sufficient quantitative data for adequate processing, with some candidates presenting raw data and not processed data. In some cases, no raw data was presented. Associated qualitative data is becoming more common and it was clear that teachers had taught candidates that observations made during the experiment will assist them in determining the validity of the data and in turn strengthen their conclusion. (NOTE: The use of pooled data will be inappropriate for the assessment of individual investigations assessed for the new, May 2018, IA as these are supposed to be the candidate's own individual effort.)

Moderators commented that DCP seems to be the criterion in which there is a greatest variation in application in what teachers are expecting and teaching. To gain a complete for DCP aspects 1 or 2, candidates need to include descriptive titles for each data table. Errors or uncertainties still seemed to be an area of confusion. Every header requires appropriate units along with the error margin. In addition to mechanical errors, errors could be caused by a fault in the device used or the person handling it. A systematic error cannot be noted from one value and therefore should relate to processed data; it is commonly only visible through graphical analysis. Human error (e.g. reaction time) is commonly misunderstood and overestimated. It is difficult to identify a reaction time from a single reading and it is only through looking at the mean value and the spread of data / graphical analysis where an insight into reaction time may be more apparent. For the purposes of the IA, it is acceptable for uncertainties (not errors) in raw data to reflect the instrument (rather than the person) being used.

Moderators are looking for a brief statement justifying why the candidate gave a particular value of uncertainty for both raw and processed data. The number of decimal places must reflect the precision of the measuring instrument and uncertainty. Teachers need to remind candidates that the processed data must be to the same degree of precision as the raw data and this was often not the case as candidates were recording data to a higher degree of precision.

Class data may be required for the candidate to obtain to sufficient data for significant data processing and determination of uncertainties. Candidates in general are either presenting their own data first or by clearly identifying which is their own data in a pooled data table, which is great to see.

When calculations are made it is important that the pathway to the answer is clear. This does not mean there has to be a worked example but a result that springs up out of nowhere should not be credited. Those using spreadsheets such as MSExcel should consider taking a screen shot of the app used, to show the data used and results gained (for example see the teacher support material on the OCC, investigation 10, page 8). Most candidates managed the basics, for example, means and standard deviations. Nevertheless, there were still candidates who tried to apply standard deviation to a sample size that was too small.

Candidates should explain their choice of statistical analysis with reference to the available data and evaluate whether it will lead to valid conclusions. Teachers need to continue to remind

candidates that a large standard deviation does not necessarily show data is unreliable when using humans as subjects; it just shows a wide spread. When IA involves many different subjects this large standard deviation is probably to be expected in that there is the possibility of unreliability - this is where qualitative data from the experiment can help explain things.

Many candidates were using significance tests from t-test to ANOVA. Although good, they need to be appropriately applied and there needs to be sufficient justification for the processing to be followed when the new IA criteria are examined in May 2018. Candidates need to be encouraged to state a statistical methodology clearly, prior to the collection of data. Use of programmes, such as Microsoft Excel, which calculates statistics, such as a p-value or a correlation coefficient, is useful but the candidate needs to know what the value actually represents.

It is not possible to give specific guidelines on the amount or type of data to be collected (sample size or number of variables), or how it should be processed. These things will depend on the nature of the investigation. Appropriate sample sizes and the reliability of statistical methods depend on what is being measured. The following suggestion should only be used where a candidate considers that it is appropriate for their investigation.

>30 is considered a large sample,

15-30 a small sample,

5-15 a very small sample,

<5 is usually considered too small a sample to apply tests like the t-test.

Candidates should be encouraged to complete a full analysis of their data by using statistical techniques that are appropriate to their analysis and data. Many did not seem well coached in basic statistics and relevant tests, which would assist them in completing a proper analysis. If a teacher does not feel confident explaining suitable statistical analyses, then it would be worth seeking help from colleagues. For example, students need to be clear about the use of the coefficient of determination (r^2) and the correlation coefficient (r) which were commonly misinterpreted.

As mentioned earlier, it was great to see some candidates applying t-testing: they should state why they chose a certain t-test (e.g. unpaired, 2-tailed) and demonstrate their understanding by commenting on the p value. Some candidates applied multiple group t-tests (i.e. comparing 3+ groups); however, the correct analysis involves an analysis of variance (ANOVA). This is usually a one-way ANOVA (i.e. comparing one variable). Candidates who did use an ANOVA (extended statistical testing), and calculated a significant p-value, did not continue with a post-hoc test (i.e. Tukey's Honestly Significant Difference). A post-hoc test will reveal where the difference(s) exist and must be conducted. If under the new IA structure candidates use the Mann–Whitney U test (i.e. analogous to the ANOVA), a non-parametric test of the null hypothesis, a rationale of a non-parametric technique versus a parametric technique needs to be provided.

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Presenting processed data on a graph is expected and indeed required for full assessment under DCP. Teachers need to be aware of this requirement and that candidates encountered problems adding axis labels and headings to computer-generated graphs. Teachers must explain how to add error bars for both line graphs and bar graphs, encourage candidates to practice these in a software tool such as Excel, and show that they understand their significance. Common errors that should be avoided are: ensuring that a graph has only one descriptive title (check that it doesn't have two identical titles); plotting several graphs when one would be sufficient; and presenting data from which nothing could be derived.

Moderators stressed the need for teachers to spend more time on teaching the fundamentals of how to process data, and the appropriateness of visual forms of such graphical representation. Sketching a graph of the data before using a graphing program can be very helpful and save a lot of time.

Where moderators had to reduce teachers' marks it was for the following reasons:
- Data (raw or processed) were inadequately presented.
- Tables and graphs did not have a descriptive title containing both the dependent and independent variables.
- Units missing in the table column headings (note: SI units should be used).
- No uncertainties were given in the column headings of tables of data collected using measuring instruments.
- There were inconsistent decimal places in the same data column.
- The decimal places did not correspond to the precision of measurements.
- The processed data (2 decimal places) on occasions had a higher degree of precision than the raw data.
- The absence of associated qualitative observations where they were valuable.
- The absence of statistical treatment of the data when it was possible and desirable.
- Raw data was plotted in graphs that did not actually reveal anything (Note: raw data can be plotted to derive maxima, minima, optimal rates, intercepts or to reveal correlations).
- Raw data was plotted when the mean should have been calculated and plotted (commonly the mean was calculated and then ignored when plotting graphs).
- Adding a straight line of best fit even when the data clearly shows a curved distribution.
- There was no presentation of uncertainties in graphical data either by using trend lines or error bars or uncertainty ranges on the axes.
- Error bars, when used, were not identified or accompanied by an explanation of what the values meant.

Complete may not mean perfect but when the mistakes are consistent they will have an impact on the moderated marks.

Conclusion and evaluation (CE)

Conclusion and evaluation was generally weaker across the board this year, as many candidates failed to score full marks. However, CE continues to be best assessed when candidates have designed and performed the investigation themselves.

Investigations that lead to trivial amounts of data will lead to limited discussion of results and weak conclusions. Insufficient data will not reveal uncertainties and this has an impact on evaluation. So although each criterion is marked on its own merits there will be a knock-on effect through an unfocused research question to a poorly designed investigation that collects a limited amount of data, permitting limited processing, leading to a weak conclusion and evaluation. Moderators were also concerned about those candidates who did not take time to interpret their data clearly; who stated a conclusion leaving it to the reader to verify if the data actually supported it. Weaker candidates also failed to refer back to the original research question.

In the new programme, for IA's examined from May 2018, results from simulations will be acceptable, so long as the simulation produces realistic data that can be processed. Simulations are particularly useful if results from a virtual experiment can be compared with those generated by a real one.

To maximize the marks in CE (aspect 1) candidates must include data from their results to back-up their findings and must refer to the appropriate statistical test to discuss the significance of their data. Candidates need to think beyond the given data to provide a justification based on a reasonable interpretation of the data. Stronger candidates added value to their own data findings by referring to or comparing and contrasting with existing data or theory. Anomalies were sometimes identified and excluded; however, this should be developed further through a discussion of the possible origin of these anomalies.

Candidates often constructed three horizontal rows corresponding to CE aspects 2 and 3: (1) weakness; (2) significance of error; and (3) suggested improvement. Candidates in some schools show that they have developed a mature sense of criticism of their investigation with their evaluation of results being based upon a balanced critical analysis of the data. Weaker candidates often commented on mistakes and lack of numbers in their sample rather than methodical errors or ways to improve the investigation. Candidates need to be reminded that they should describe at least 3 major weaknesses (more if they are present), which is often the case. Despite the inclusion of separate rows for the significance of the weakness which helped to draw candidates to the importance of discussing the significance in addition to identifying the weaknesses, this continues to be an area that requires attention. When discussing the significance of the weakness, the teacher needs to highlight that they must refer to their actual data or back up the issues they identified in order to justify their statements and gain a complete for CE aspect 1; this was commonly marked over generously. Moderators commented that modifications need to be specific rather than hypothetical and superficial; they are marked overgenerously by teachers. Evaluation is a good discriminator of high achieving candidates and teachers would do well to remember this when they are marking their candidates' work.

Manipulative skills (MS)

Evidence on the 4/PSOWSEHS forms indicates that most candidates are being exposed to a sufficient range of investigations. This ensures that manipulative skills can be assessed correctly. However, many moderators notice that some schools are attributing 6/6 for the whole sample for this criterion. There appears to be very little discrimination between candidates, yet the moderated marks suggest that that the candidates in the class do not all have the same capacity for experimental work.

Non-moderated criteria will no longer be present in the new programme with IA submission from May 2018.

Recommendations for the teaching of future candidates

Design

- Guide candidates away from repeating classic investigations or working on the same research question when they design their own investigations.
- Set open-ended themes with enough scope to provide a variety of research questions for the whole class.
- Ensure that investigations have the potential to generate sufficient data for substantial processing.
- Counsel the candidates on the safety issues, ethics and feasibility of the investigations they design.
- Teachers should give candidates experience in identifying independent, dependent and controlled variables.

DCP

- Encourage candidates to make additional qualitative observations about their experiment. It is good practice for them to keep a log book.
- Ensure candidates keep their candidates' anonymity and refer to them by a number and not personal names.
- Teach candidates that each data table should include a descriptive title (containing both the dependent and independent variables and if relevant, the error margin), and axes should be labelled with appropriate units.
- Teach candidates that the number of decimal places must reflect the precision of the measuring instrument and all decimal places must be consistent in raw and processed data.
- Although many schools correctly appreciate errors and uncertainties, this remains a weak area. Teachers need to address the appropriate treatment of uncertainties in lab work.
- Teach candidates not to plot graphs of raw data if nothing can be derived from them.
- Only processed data should be presented graphically and the x and y axes must be labelled clearly. When candidates use error bars on graphs, there needs to be an indication of what these values represent.
- Teach candidates how to add error bars for both line and bar graphs, and to practice these in a software tool such as Excel.

CE

- CE Aspect 1 (concluding) should include data to back up findings and reference to the appropriate statistical test to discuss the significance of the data.
- Challenge candidates to add value to their own data by comparing and contrasting with existing data or theory before starting an investigation and again once the results are complete.
- Citations of references should be presented correctly; Extended Essay guidelines give very helpful information.

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General
- Many schools allow candidates only two opportunities to earn their best marks. It is recommended that after candidates become familiar with the expectations of IA they have a number of opportunities to be assessed (perhaps 3 or 4) from which the highest two of each criterion are used for their IA mark.
- Read the feedback from this session and act upon it. This is available from your IB Coordinator.
- Share the IA criteria with their candidates and explain them.
- Enclose all instruction sheets and/or summaries of oral instructions for the investigations in the moderation sample. Most schools complied with this requirement. When Data collection and processing (DCP) is being assessed, the method designed by the candidate or provided by the teacher is required.
- Internal standardisation between colleagues is essential.
- Check that all the parts of the 4/PSOWSEHS form are completed correctly.
- Atypical candidates should be replaced in the sample. These would include candidates whose work is incomplete or transfer candidates where a substantial part of their work has been marked by another teacher.
- Consult the Online Curriculum Centre (OCC) for Teacher Support Material (TSM) for the IA component of the course if this has not been referred to. The TSM shows how the criteria should be applied in the assessment of practical work. It also consists of a series of investigations or part investigations by candidates that have been assessed by moderators using the new assessment criteria.
- Teachers need to make regular use of the IBO OCC site to help connect with other teachers, share IA ideas and how to further develop the programme.
- Familiarise yourself with the new May 2018 programme's requirements for practical work and internal assessment.

Further comments

It was evident that some teachers linked and worked with other colleagues to ensure internal standardization had taken place. Teachers are encouraged to work with the other science subjects where appropriate, to ensure common understanding of standards.

Clerical procedure
- Only one 4/IA form is required per school and this must be signed by all the teachers for your school's sample.
- Many schools are still sending their samples without teacher instructions and failed to include the 4/IA sheet.
- Teachers must ensure that the most up-to-date version of the 4/PSOWSEHS form (available on the OCC) is used and filled in correctly as this continues to often not be the case. It is crucial that schools refer to OCC to gain guidance on filling in forms and complete this basic task correctly. It is helpful if the full IA titles (candidate) of investigations are included on the 4/PSOWSEHS form as this makes it easier for the moderator to match up the candidate work for assessment.
- The hours allocated for practical work should not include time allocated for write-up of

investigations (D, DCP & CE). The hours allocated should be recorded only once on the form, and grades, where appropriate, (on the same line for a single investigation) awarded for D, DCP & CE.

- The criteria for the sampled work might be flagged using a cross but the actual marks are not filled in.
- There continues to appear to be confusion about what the cross was for in the boxes under the different criteria and for each investigation; some schools used this to identify the practicals sent but several used this to show all the practicals that had been assessed. The cross is to identify the top 2 grades and to identify the work being sent to the examiner as part of the sample.
- Teachers regularly include the "complete", "partial" and "not at all" breakdown of their marks. When this is combined with comments and feedback to the candidates it makes it very clear how the teachers were awarding marks. Unfortunately, a growing trend has been to return clean copies with no comments.
- The effort of those teachers who take a lot of time and trouble to prepare their Internal Assessment sample is very much appreciated. They should be congratulated for their efforts and their candidates will reap the benefits. It is much easier for a moderator to support a teacher's marks when there are clear, readable notes accompanying the sample. Although some teachers are having problems applying recommendations given in the feedback, there are encouraging signs that many are responding to it.
- There is a recurrent problem concerning the information provided by the teacher. This directly affects the progression of the moderation. Teachers must enclose all the instruction sheets and/or adequate summaries of oral instructions for the investigations in the moderation sample. Some schools are still not doing this, or they are so cursory that they are not much use at all.
- Only a few teachers are failing to design practical programmes with sufficient numbers of hours. Some, however, have been observed to grossly inflate the time spent on an activity and focusing on the core topics only.
- Some schools are sending photocopies of the candidates work. Usually these are of good quality; problems may arise from mono photocopies of colour graphs and diagrams which may be unclear. The originals must be sent and a photocopy kept back.

Ethics and Safety

In many schools, the IB Animal Experimentation Policy (available of the OCC) is adhered to while in a few it seems to be disregarded. Moderators commented on an increase in investigations that were unsafe or unethical. These schools should review the investigations carried out in light of this policy and ensure that all experiments are considered from an ethical point of view. The IB does not wish to inhibit investigations but it does want to stimulate a responsible attitude towards experimentation on animals. Any proposed experimentation involving animals, including humans, should result in a discussion between teacher and candidate based on its ethical implications and how to refine the experiment to alleviate any harm or distress.

SEHS will inevitably involve investigations using humans and teachers should carefully consider the approach to experiments on human physiology. Using fellow candidates or other people for investigations into the effect of exercise on the heart rate can be considered unsafe

if the health status of the volunteers is not determined first. Investigations on human subjects must not place the volunteers at risk. Safety must be paramount in investigations. As stated in the "Guidelines for the use of animals in IB World Schools' in the IB animal experimental policy any experimentation involving human subjects must be with their direct, legally obtained written permission. Some schools are already expecting their candidates to use a proforma for the signed consent of the participants in experiments. This is essential ethical practice but moderators report that it is still uncommon.

Investigations involving any body fluids must not be performed due to the risk of the transmission of blood-borne pathogens. The only exception would be an investigator using their own saliva or sweat. Experiments that administer drugs or medicines or manipulate the environment or diet beyond that which can be regarded as humane is unacceptable in IB schools. In other words, exposing candidates to caffeine, alcohol or energy drinks is not appropriate as you are exposing subjects to conditions outside their normal environmental tolerance limits. The consensus amongst many science teachers is that consuming recommended dosage for nutritional ergogenic aids is not likely to lead to significant changes in behaviour and, if any changes do take place this may be due to confounding variables. This is especially true given the small sample size and no recording of other variables in a scientific way. Therefore, ingesting sufficient nutritional ergogenic aids, such as caffeine tablets, creatine, sports drinks, protein supplements (legal over the counter products) to lead to a statistically significantly difference in results would require going beyond what should be ingested by humans in the short time frame.

Dissections are a special case in SEHS and the guidelines are quite clear on this. The practice of dissections because they are a traditional part of a course is not an adequate reason for including them. Including them to study form and function in the distribution of organ-systems, organs and tissues is valid. Much of this can be done using simulations or dissections of organs purchased in butcher's shops. Nevertheless, this kind of investigation would be inappropriate for assessment as it rarely produces quantitative data.

New features of the IA (May 2018) that need to be considered:

May and November 2017 are the final sessions of the current criteria and from May 2018 new criteria need to be applied. These can be found in the latest Sports, exercise and health sciences guide (first examinations May 2018) on the OCC. The marking is arranged by bands, which may take a little getting used to. Exemplar investigations on the Teacher Support Material should help here.

There are a number of new features that teachers should be aware of:
- The purpose of the investigation needs to be expressed clearly in the report and there needs to be clear evidence of personal engagement.
- The investigation cannot be a simple repeat of a classic investigation; however, it is possible to adapt and extend from a traditional investigation.
- The individual approach means that candidates cannot work in groups or work on the same investigation and share data.
- Although the assessment of manipulative skills will no longer be part of the internal assessment, evidence of the consideration of safety, ethics and environmental impact will be expected for the Exploration criterion.
- Given that 10 hours are allocated to the Individual Investigation, a significant amount of data should be collected. This will impact on Personal Engagement, Exploration, Analysis and Evaluation.

- Correct format of citations/bibliography is necessary. URLs alone are insufficient. This will contribute to the Communication criterion
- Page length is limited to 6-12 pages. Format, e.g. font size and sizes of images and graphs will contribute to the Communication criterion. Text and graphs should be large enough to read clearly.
- As well as suggested improvements to modify the investigation, suggested extensions to the study are expected for the Evaluation criterion. As with the improvements they need to be realistic and precise.
- All selected candidates IA work is submitted and assessed electronically through the new process of dynamic sampling (five, eight or ten scripts depending on the number of candidates registered).
- Submitted work to be annotated by teacher, with comments that will help the examiner understand the reasons why particular marks were awarded.
- Only if significant adjustments are made to the teacher's marking will schools receive IA feedback.

Standard level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 7	8 - 12	13 - 16	17 - 19	20 - 21	22 - 24	25 - 30

General comments

Overall, the exam appeared to be a little easier than the previous year, with a mean difficulty index of 62.65 compared to the 2016 mean of 53.93. The spread of difficulty and discrimination indicated that all questions were appropriate, as 35.74% answered the most difficult question correctly. Conversely, there were two questions that over 90% of candidates answered correctly.

The areas of the programme and examination which appeared difficult for the candidates

There were five questions where fewer than 40% of candidates answered correctly; 6, 14, 18, 3, and 29.

These questions are not particularly related so it does not necessarily highlight a sub-topic that requires greater focus.

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The areas of the programme and examination in which candidates appeared well prepared

There were six questions where at least 80% of candidates answered correctly; 27, 28, 25, 17, 21, and 9.

This indicates that candidates were very well prepared around fitness testing and skill classification.

The strengths and weaknesses of the candidates in the treatment of individual questions

Q1: Sixth most difficult question. I suspect that this is due to confusion over the pelvic girdle as part of the appendicular skeleton.

Q2: Seventh easiest question, suggesting positive knowledge of the skeletal system.

Q3: Fourth most difficult question. A surprising number of candidates believed that the radius and carpals created hinge joints.

Q4: Mid-range difficulty.

Q5: Mid-range difficulty.

Q6: Most difficult question on the paper. Responses were fairly evenly spread across all four options, indicating that candidates are uncertain over what vital capacity is.

Q7: Mid-range difficulty.

Q8: Mid-range difficulty.

Q9: Sixth easiest question, suggesting positive knowledge of the ventilatory system.

Q10: Mid-range difficulty.

Q11: Seventh most difficult question. Many incorrectly chose option B, meaning that they believed that aerobic glycolysis was quickest to re-synthesize ATP.

Q12: Mid-range difficulty.

Q13: Mid-range difficulty.

Q14: Second most difficult question. Answers were evenly split between options C and D. D was the correct answer, recognising that both metabolism and catabolism as taking place when ATP is converted to ADP and phosphate. Those selecting option C did not recognise the role of metabolism.

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Q15: Mid-range difficulty.

Q16: Mid-range difficulty.

Q17: Fourth easiest question, suggesting positive knowledge of centre of mass.

Q18: Third most difficult question. Although many answered this incorrectly, responses were fairly evenly spread, indicating that candidates were largely unaware of rationale behind running phases.

Q19: Mid-range difficulty.

Q20: Mid-range difficulty.

Q21: Fifth easiest question, suggesting positive knowledge of skill classification.

Q22: Mid-range difficulty.

Q23: Mid-range difficulty.

Q24: Mid-range difficulty.

Q25: Third easiest question, suggesting positive knowledge of transfer of learning.

Q26: Mid-range difficulty.

Q27: Easiest question, suggesting positive knowledge of fitness testing.

Q28: Second easiest question, suggesting positive knowledge of fitness testing.

Q29: Fifth most difficult question. Many incorrectly identified the OMNI or CERT scale as a measure of perceived exertion.

Q30: Mid-range difficulty.

Recommendations and guidance for the teaching of future candidates

Clearly, candidates are very well prepared, which is highlighted by the increased mean mark. There are no particular sub-topics that require consideration.

Standard level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 5	6 - 11	12 - 16	17 - 22	23 - 29	30 - 35	36- 50

General comments

There were many candidates leaving a number of questions blank, with some candidates leaving the vast majority of the paper blank, which is concerning.

The understanding of the core content and what is required in each command term was variable. For example, in question 2b and 5a where the candidates were required to 'distinguish' for two marks, candidates made just one statement regarding the main difference but this was not sufficient to achieve all the marks available for the question. In addition, the command term 'evaluate' was used in 4c; candidates commonly described the method of the fitness test rather than commenting on the strengths and limitations of the method.

Overall the understanding that when they are asked to 'calculate' the equation needed to be shown, was good. The students were able to outline the connective tissues of joints and identify functions of red and white blood cells and platelets. The candidates were also able to outline a variety of types of feedback. Additionally, the students utilised the additional answer booklet with much more success.

Candidates struggled with basic concepts such as, identification of compact bone; distinguish between fibrous and cartilaginous joints, and outlining common characteristics of muscle tissue. Candidates generally managed to recall the adaptations of the heart due to cardiovascular exercise. Confusion between the meaning of cardiac output, VO_2max, stroke volume, and heart rate was common. Explaining motor skill profiles, memory aids, and essential elements of generalized training program were a challenge. Many students struggled with the role of insulin as there was a frequent confusion between insulin and glucagon and between glucagon and glycogen. Candidates were challenged by explaining the role of ATP, acetylcholine and reciprocal inhibition.

In section B question 4 was the most popular selection followed by question 5 then 6.

The areas of the programme and examination which appeared difficult for the candidates

- Some candidates missed providing the full equation for the command term "calculate" as they provide just the answer.

- Reasons for randomisation were not well understood.
- Adaptations of the heart caused by cardiovascular training.
- The overall understanding of stroke volume, heart rate and cardiac output and what this means when endurance training takes place.
- Using the data to explain the difference between the peak VO_2 of boys and girls
- The difference between learning and performance.
- Motor skills profiles.
- Descriptions of concentric and eccentric muscle contractions.
- Complete understanding of the role of ATP during muscle contraction.
- Closed loop theory.
- Strengths and limitations of the Harvard Step Test.
- Role of insulin within the body.
- Describing the types of movement of a ball and socket joint.
- Explaining oxygen exchange at alveoli.
- Outline characteristics of skeletal muscle tissue.
- Describing coding and chunking as memory aids.
- The process of reciprocal inhibition and application in a real-life situation.

The areas of the programme and examination in which candidates appeared well prepared

- Identifying and using data to calculate differences
- Adaptations of the heart due to endurance training
- Explain the role of ATP in muscle contraction
- Outline the types of connective tissue
- Describe the functions of blood cells
- Characteristics of the lactic acid system
- Ways variety can be introduced in long-distance running.
- Connective tissues of joints.
- Functions of red and white blood cells and platelets.
- Distinguishing between fibrous and cartilaginous joints.
- Some elements of the generalized training program (warm-up and cool-down)
- Cardiovascular drift.
- Outlining types of feedback.
- Describing association as a memory aid.

The strengths and weaknesses of the candidates in the treatment of individual questions

1a

While many candidates clearly laid out their working, some still ignored the command term "calculate" and provided just the answer, depriving themselves of a valuable mark.

1b

Most candidates were able to get 1 mark in this question by recognizing that the relationship between percentage of heart rate maximum and VO_2max was positive or that the relationship was a positive acceleration. Very few candidates were able to identify both trends. This is a case where candidates need to check the number of marks and ensure they answer with an equal number of points.

1c

Many students identified decrease in bias as a reason for randomisation. Few students referred to the ability for it to assist with causality in an experiment. The most common response was that randomization improves accuracy, validity and reliability, which is too vague to award a mark.

1d

Many students were able to access two marks for this question. A number of students focused on general cardiovascular adaptations rather than on cardiac (heart) adaptations, or when referring to HR were vague and did not refer to a decrease in <u>resting</u> or <u>exercise</u> HR relative to exercise at similar intensities to pre-adaptation exercise.

1e

Many students did well on this question correctly identifying at least one way in which variety could be introduced.

1f

Almost all students were able to make the correct identification.

1gi and ii

Too many candidates struggle to recall the components for the product of stroke volume and heart rate. Many of the students who correctly recall the components for the cardiac output, express the relationship as subtraction; this earns marks (ECF) for those students in question gii. However, several students did not manage to calculate the values correctly from their own formula or ignored the command term and provided just the answer (as happened in 1a) losing a mark. The students should be reminded that in paper 2 use of calculator is allowed and should be used to reach the correct answer.

1h

Many candidates are unable to achieve more than one mark as they did not **refer to the data** to explain the difference in peak VO_2 as the question asked.

2a

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Many candidates misidentify compact bone as hard bone or spongy bone. This is a question where many candidates did not fully read the question.

2b

This proved to be a very challenging question to most candidates. Students were not able to differentiate adequately between learning and performance and commonly made the mistake of describing performance as perfect execution of an action. Many of the stated examples were too vague.

2c

Many candidates were unable to identify any skill profile continuums. The most common correct identification was use of gross skills in the freestyle swimming events. However, many of those who stated the correct named continuum, ignored the command term which required an explanation.

3ai and aii

Candidates struggled to describe the two muscle contractions correctly. Commonly there was a lack of reference to load or tension with the movement.

3b

Overall this was a positive question for many candidates. Many candidates were able to achieve at least 1 mark, identifying the role ATP had in providing energy for muscular contraction, however fewer candidates were able to link the role of ATP into the sliding filament theory.

3c

This was a very challenging question. Some students referred to the Welford's model of information processing and others used Adam's closed loop theory.

Section B

4a

Most students were able to answer this question well; however, some candidates listed the connective tissues and did not provide an outline.

4b

Most students were able to answer this question well.

4c

Students struggled to evaluate the Harvard Step Test. Many students outlined the protocol for the Harvard Step Test while providing no reflection on strengths and limitations of the test.

Students demonstrated knowledge of assessment statement 6.3.3 where candidates have to outline the tests, but more focus is required in class to enable students to evaluate the tests.

4d

Few students gained full marks on this question. The most common correct response to this question contained reference to insulin contributing to the blood sugar regulation. Some candidates focused on providing the role of glucagon or diabetes and therefore explained a large amount of irrelevant material.

4e

While candidates identified movements of this joint they were not able to describe the movements. Candidates should be advised that full marks cannot be awarded for a mere list of types of movement when a "describe" command term is used.

5a

Many students were able to answer this question well. There was uncertainty regarding the amount of movement for each joint.

5b

Candidates were not able to describe the elements of the generalized training program well. Commonly students referenced only warm-up and cool-down. Many candidates misconstrued this question to be about the principles of training and principles of overload. When candidates were able to identify the correct elements, they found it hard to describe the role or activities that form part of these elements.

5c

This question was still a challenge for some students; however, many students were also able to outline some parts of the process very well.

5d

Many students answered this question adequately.

5e

Candidates struggled to explain the oxygen exchange at alveoli often delivering responses that were too vague or discussed carbon dioxide as well as discussion on the pathway for ventilation.

6a

This was a poorly answered question for the few candidates that selected Q6. This is an area that requires review during class teaching.

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6b

Many candidates achieved 1 mark but struggled with the process of transmission of the action potential across the synapse and the effect this had on the muscle. Students had a tendency to mix up ACh with ATP when answering this question.

6c

This was a well-answered question; however, students failed to earn full marks if they did not provide a brief account of each type of feedback.

6d

Students did well describing association. Chunking and coding were commonly described in vague terms or confused with each other.

6e

Many candidates were unable to access marks for this question. The length of response in relation to the number of marks awarded was often very poor. Candidates were unable to use technical language such as agonist and antagonist appropriately. Many candidates failed to complete a movement analysis example for kicking a ball.

Recommendations and guidance for the teaching of future candidates

- Read the question carefully to ensure that the intent of the question is clearly understood.
- Learn the command terms and consider how the question needs to be answered.
- Although most students answer one full question in section B (as instructed), there are still some students who tried to answer part questions from questions 4, 5 and 6.
- Some students are still writing outside of the boxes, which makes it difficult for the examiners to read, and may mean that their responses are missed in the scanning process. Discuss this with students and ensure that they use the pages at the end or request extra paper.
- Candidates should check and proof read their answers against the marks that are allocated to the question to ensure that they have given a point for each mark.
- Candidates should never leave an answer blank. They will not be penalised for writing wrong answers; additionally, the writing process may trigger their memory of the required knowledge.
- Teachers should look through the question paper and mark scheme carefully, cross reference this to the assessment statements in the guide and add this information to their teaching material.
- Teachers and schools should reflect on the number of hours that they have in order to teach this course.

Standard level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 5	6 - 11	12 - 16	17 - 21	22 - 25	26 - 30	31 - 40

General comments

On compare and contrast questions, we are seeking similarities and differences. Some candidates presented several good differences with no similarities.

There were several candidates who answered each option. Some then crossed out the options they discarded but this is something to be aware of.

There were some papers where the handwriting was barely legible.

It was pleasing to see that new schools achieved a similar average mark and distribution to established schools.

The areas of the programme and examination which appeared difficult for the candidates

There were two questions in particular that highlighted difficulty for candidates. The first was in option C, referring to WHO physical activity guidelines; the second was in option D, referring to water distribution.

The areas of the programme and examination in which candidates appeared well prepared

The first question in each option was generally well answered, demonstrating that candidates were able to interpret and calculate basic statistics.

70% of candidates successfully responded to questions 2a (body temperature) and 3a (definition of ergogenic aid).

Overall however, there was no real pattern regarding questions that were commonly answered very well. Although high marks were achieved, these were accumulated differently. This suggests that there were no easy questions.

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The strengths and weaknesses of the candidates in the treatment of individual questions

Option A

Candidates generally appeared well prepared for this option. None of the 9 least well answered questions were from this option. However, there were some questions that were answered less well than expected.

1c) Many candidates were able to identify the greater sweating rate for Experimental group compared to Control; however they didn't identify the increase in sweat rate for both groups in post-training.

1d. Candidates must address question. Some simply explain the process of sweating or explained cardiovascular adaptations.

2b. There were many vague responses about heat stroke that did not address the question. Students were quite weak at 'explaining' the characteristics.

3b. Generally well answered but some too vague such as referring to "heart problems" rather than specifically outlining a heart problem.

3c. I was disappointed with the number of candidates that did not know what beta blockers were. Some confused them with diuretics, others with muscle-enhancing substances. Those who did know, generally answered it very well and obtained full marks.

Option B

This was less well answered than option A; only questions 6b and 8 were poorly answered. Generally, good candidates were able to obtain some, but not full marks.

5c) Many students were able to identify males having higher scores than females (differences) but many had difficulty in identifying the similarities.

5d. There is a common over-simplification about extrinsic motivation that it must come from a source external to the individual, which is not true. It can also be internally derived but as a means to a specific end. For example, undertaking a behaviour to remove feelings of guilt (introjected regulation) is a common form of internally-derived extrinsic motivation.

6b. Many did not understand the interactionist approach to personality but predictably made a guess at people who interact with others. Most were able to describe the interaction between the individual and their environment. This was commonly awarded 1/3 marks.

7b) I was surprised at how poorly this question was answered. Most candidates indicated that it measured Anxiety (and this could be used to monitor progress or inform interventions). Many failed to discuss the other advantages.

8) Many candidates did not answer this well and gave quite vague responses. It did discriminate those students who really knew the concepts and those that did not.

Option C

Candidates appeared appropriately prepared for this option but there was limited knowledge of WHO guidelines, demonstrated in Q12a.

10b) Many students were able to pick out 1 or 2 points; however, many repeated themselves with regards to technological changes.

11. Many did not elaborate on the basic weight loss equation and only received one mark.

12a. Many struggled with this question, not recognising it was pointing to WHO guidelines. Many also mentioned diet and other health factors not relating to exercise guidelines.

12b. This is fairly consistent over the past few years, but some misinterpret what is meant by a risk factor and explain only consequences.

Option D

Although candidates appeared largely well-prepared, Q15 was poorly answered.

15b. Many did not score any marks here, missing the water content of muscle and instead focusing on hydration/sweat.

Recommendations and guidance for the teaching of future candidates

Ensure that candidates are aware of the requirements of each command term. For example, compare and contrast requires both similarities and differences, evaluate should include strengths and weaknesses, and discuss or explain cannot be a list.

For option C, it is imperative that candidates are able to support their arguments regarding advice on physical activity. This includes being aware of published guidelines.

For option D, pH levels and water content of muscles is fundamental knowledge.

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