Sports, exercise and health science

Overall grade boundaries

Standard level

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 15	16 - 31	32 - 44	45 - 55	56 - 67	68 - 78	79 - 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. From different regions around the world the quality and expectations of candidates varies widely, and it is hoped that as teachers gain experience and understanding, regional variations will reduce. 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. Examiners commented that candidates performed according to teacher strengths and weaknesses, as similar candidate strengths and weaknesses were reflected within each sample. For example, there were schools that submitted outstanding designs and conclusions with quality literature reviews and very thorough background research along with reference to ethical issues. Some other schools appeared to struggle with data collection and processing, whereas others had outstanding statistical analyses and/or conclusions and evaluations but were challenged in formulating research questions and designs. Examiners also commented on how there was often a clear

distinction between quality of work in schools where SEHS is now established, compared to schools who are entering students for the first or second time.

Many 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. The International Baccalaureate (IB) does not wish to inhibit investigations but it does want to stimulate a responsible attitude towards experimentation. If necessary, teachers may need to make adjustments to their practical scheme of work especially where human volunteers are involved.

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 for Design aspect 1, 2 & 3. 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; however full marks could often not be awarded, as there was often little discussion of 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, especially in new schools to establish trends or

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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. 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 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. Many students are also processing data and presenting participant averages rather than averages of the independent variable's treatments. Associated qualitative data is becoming more common in experienced schools 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 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 applied appropriately 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.

Presenting processed data on a graph is required for full assessment under DCP. Teachers should explain how to process data, appropriate graphical representation, how to add error bars to line and bar graphs, and encourage candidates to practice using e.g. Excel. Common errors that should be avoided are: ensuring that a graph has only one descriptive title; plotting several graphs when one would be sufficient; and presenting data from which nothing could be derived.

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 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

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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 produce trivial amounts of data will lead to limited discussion of results and weak conclusions. Insufficient data will not reveal uncertainties and will have 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. Strong candidates have developed a mature sense of criticism of their investigation with their evaluation based upon a balanced critical analysis of their 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 should describe at least 3 major weaknesses (or more if they are present). 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, candidates must refer to their actual data or back up the issues they identified in order to justify their statements to gain a complete for CE aspect 2; this was commonly marked over generously. Moderators commented that those students whose scored highly for CE had a clear understanding of statistics and had taken participant by participant qualitative observations so as to use them to make sense of outliers, standard deviations or even just slightly higher or lower averages. Suggested modifications should be specific rather than hypothetical and superficial; they are marked overgenerously by teachers.

Evaluation is a good discriminator of high achieving candidates in both the current and new IA criteria as of May 2018 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

Familiarise yourself with the new May 2018 programme's requirements for practical work and internal assessment. The new criteria are listed in the subject guide, which can be found on the Programme Resource Centre (PRC). There are sample IAs in the Teacher Support Material.

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
- 10 hours are allocated to the Individual Investigation, so 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 be marked in 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

Further comments

Ethics and Safety

In many schools, the IB Animal Experimentation Policy (available on the PRC) is adhered to while in a few it seems to be disregarded. 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 identify and alleviate any potential 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.

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. 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.

ICT coverage

There was evidence of sound ICT coverage and some schools have made an effort to equip themselves with the necessary materials to carry out data logging. However, data loggers must

be used with care in investigations. Teachers and candidates are strongly advised to read the relevant section of the subject guide and possibly target ICT as an area to develop.

Graph-plotting using software continues to be widely used and candidates should be taught how to use it correctly. They need to select the most appropriate form of graph, and ensure that appropriate labels for, e.g. title, axes, legend are added if necessary.

Standard level paper one

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 5	6 - 11	12 - 16	17 - 19	20 - 23	24 - 26	27 - 30

Statistical analysis

The overall performance of candidates and the performance on individual questions are illustrated in the statistical analysis of responses in the grids below. The numbers in the columns A–D and Blank are the numbers of candidates choosing this as their answer. The shaded cell indicates the correct question.

The difficulty index (perhaps better called facility index) is the percentage of candidates that gave the correct response. A high index thus indicates an easy question.

The discrimination index is a measure of how well the question discriminated between the candidates of different abilities. In general, a higher discrimination index indicates that a greater proportion of the more able candidates correctly identified the key compared with the weaker candidates. This may not, however, be the case where the difficulty index is either high or low.

Standard level paper one item analysis

Number of candidates: 347

Question	A	B	C	D	Blank	Difficulty Index	Discrimination Index
1	271	19	3	54		78.10	0.49
2	44	86	203	14		58.50	0.54
3	44	59	182	61	1	52.45	0.48
4	42	19	25	261		75.22	0.30
5	59	224	32	32		64.55	0.44
6	6	6	7	328		94.52	0.14
7	118	8	217	4		62.54	0.39
8	111	97	29	110		31.70	0.43
9	23	27	290	7		83.57	0.33
10	19	266	20	42		76.66	0.44
11	62	16	14	255		73.49	0.49
12	102	22	216	7		62.25	0.66
13	61	257	11	18		74.06	0.28
14	0	323	12	12		93.08	0.15
15	43	15	74	215		61.96	0.53
16	52	73	165	57		47.55	0.56
17	19	20	294	14		84.73	0.34
18	302	1	4	40		87.03	0.16
19	7	3	7	330		95.10	0.11
20	41	228	55	23		65.71	0.59
21	15	22	273	37		78.67	0.44
22	12	2	6	327		94.24	0.12
23	12	280	12	43		80.69	0.26
24	308	6	5	28		88.76	0.08
25	20	216	15	95	1	27.38	0.03
26	15	16	310	6		89.34	0.13
27	45	39	31	231	1	66.57	0.59
28	19	200	36	91	1	57.64	0.59
29	36	272	25	14		78.39	0.39
30	267	17	47	16		76.95	0.28

Comments on the analysis

Difficulty

The difficulty index varies from 27% (relatively "difficult" questions) to about 95% (relatively "easy" questions). The paper questions gave an adequate spread of marks while allowing all candidates to gain credit.

Discrimination

All questions had a positive value for the discrimination index. Ideally, the index should be greater than about 0.2. This was achieved in the majority of questions. A low discrimination index may not result from an unreliable question. It could indicate a common misconception amongst candidates or a really easy question. There are 8 questions with a low discrimination index (below 0.25).

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"Blank" response

There were only 4 blank responses across the cohort.

Question 25: more students got it wrong than right (216 students opted for answer B while only 95 opted for the intended response D. Upon the review of the question, both B and D were accepted. Response D has been amended in the published version of the paper.

General comments

Each session teachers are invited to submit comments about the exam on the G2 form. These comments provide valuable evidence for the senior examining team during the Grade Award meetings. It is very important for the examining team to have this feedback to help in their analysis. The six G2 forms submitted for this session were favourable to the quality of the paper. (These forms can be downloaded from the PRC.)

The mean score/mark was 21.61 (range 8 – 30). This is down compared to November 2016 which was 23.82 (range 13 – 30).

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

1.1.10   Synovial joints

2.1.3   Pulmonary ventilation

2.1.5   Neural control of ventilation

2.1.6   Location of hemoglobin

2.2.9   Systolic blood pressure

3.1.1   Micronutrients

3.1.6   Composition of the triacylglycerol molecule

3.2.2   Glycogen

3.3.1   Ultrastructure of an animal cell

4.2.2   Isometric muscle contraction

4.3.1   Force

4.3.3   Centre of mass

4.3.6   Plantar flexion as a second-class lever

5.1.1   Skill

5.1.7   Technique

5.1.8   Relationship between skill, technique and ability

5.2.5   Characteristics of short-term memory

5.3.8   Characteristics of whole–part–whole presentation

6.1.1 and 6.1.3 Standard deviation

6.3.3   Anthropometry as a way to measure body composition

6.4.1   Essential elements of a general training programme

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

1.1.5   Anatomical location of radius

1.2.3   Structures of sarcomere

2.1.7   Relative concentrations of O_2 and CO_2 in pulmonary vein versus pulmonary artery

2.2.4   Adrenaline being part of the regulation of heart rate

3.1.7   Characteristics of saturated fats

4.1.1   Sequence of neural impulse transmission to the muscle

4.2.1   Supination

6.1.5   Meaning of coefficient of variation

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

Question 1

A mid-difficulty question with a good discrimination index. D was the main distractor.

Question 2

The 5th most difficult question on the paper, which was surprising given the strength of past candidate performance in this area. This question had a good discrimination index with A and B as the main distractors.

Question 3

The 3rd most difficult question on the paper. This question had a good discrimination index with A, B, and C as evenly strong distractors. This was also surprising given that students had been exposed to this area and performed well in the past.

Question 4

Seen as mid-difficulty question with a fair discrimination index. A was the main distractor.

Question 5

A mid-difficulty question with a good discrimination index. A was the main distractor.

Question 6

The 2nd easiest question on the paper as expected from this area of the course guide. This question had a low discrimination index. Students have been exposed to similar questions in this topic area and clearly are performing well.

Question 7

This was a difficult question with A as the main distractor. The question had a good discrimination index. This is a key area of the syllabus but it proved to be a challenge for candidates to pick out the correct relative relationship between oxygen and carbon dioxide in the pulmonary vein versus the pulmonary artery.

Question 8

This was the most difficult question on the paper with a good discrimination index. The responses A and B were equally good distractors. The question proved to be more challenging than anticipated.

Question 9

Seen as an easy question with a fair discrimination index. Students have been exposed to this type of question previously and clearly are performing well overall.

Question 10

A question that proved to be in the mid-difficulty continuum, with a good discrimination index and D as the main distractor.

Question 11

A mid-difficulty question with a good discrimination index and A as the main distractor.

Question 12

This proved to be a difficult question with a fair discrimination index and A as the main distractor. The candidates still find the characteristics of saturated and unsaturated fats tricky to recall.

Question 13

A mid-difficulty question with a fair discrimination index, and A as the main distractor.

Question 14

This was an easy question with a low discrimination index. Students have been exposed to this type of question previously and clearly are performing well.

Question 15

This was a difficult question for candidates in this session. This question had a good discrimination index with A and C as the main distractors.

Question 16

The second most difficult question on the paper with a good discrimination index. A, B, and D were equally good distractors.

Question 17

Seen as an easy question, as expected, but it had a fair discrimination index. Students have been exposed to this type of question previously and clearly are performing well.

Question 18

Seen as an easy question with a low discrimination index. D was the main distractor. This is a formula which students are clearly familiar with.

Question 19

The easiest question on the paper with low discrimination index. Students have been exposed to this concept well and clearly are performing accordingly.

Question 20

A mid-difficulty question with a good discrimination index, and A and C as the main distractors.

Question 21

A mid-difficulty question with a good discrimination index with D as the main distractor.

Question 22

The third easiest question on the paper with low discrimination index. Students have been exposed to this type of question previously and clearly are performing well.

Question 23

As expected, this was seen as an easy question with a good discrimination index. D was the main distractor. It is a formula which students are clearly familiar with.

Question 24

Seen as an easy question with a low discrimination index, which was surprising given the complexity of the topic and past candidate performance.

Question 25

Initially this was the hardest question on the paper; however, upon review it was agreed that both B and D would be accepted making this one of the easiest questions on the paper.

Question 26

Seen as an easy question with a low discrimination index. Students have been exposed to this type of question previously and clearly are performing well.

Question 27

A challenging question in the mid-difficulty continuum with a good discrimination index. A, B, and C as distractors, which was surprising given the performance on the previous question.

Question 28

The 4th most difficult question on the paper with a good discrimination index. D as the main distractor. It is important to recognize that the understanding of the statistics questions is tested on Paper 1 due to their significance in data analysis during Internal Assessments.

Question 29

A mid-difficulty question with a fair discrimination index. A was the main distractor.

Question 30

A mid-difficulty question with a fair discrimination index. C was the main distractor.

Recommendations and guidance for the teaching of future candidates

Encourage candidates to take their time with the paper and read each question carefully. The candidates are expected to choose the best answer to each question even though some other responses may feel applicable.

Candidates must not leave a question blank. Where a question is difficult, look to eliminate any answers that are definitely wrong and this will help to increase the chances of them getting the correct response.

Standard level paper two

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 6	7 - 12	13 - 18	19 - 24	25 - 29	30 - 35	36 - 50

General comments

There have been many improvements in the overall responses. There has been a considerable reduction in the number of responses being left blank. Candidates also appropriately chose just one question in Section B. Candidates answered the data-based questions much more effectively and utilized the additional answer sheets with much greater success. Very few students responded outside the answer boxes provided. All students should be informed that responses that fall outside the response boxes are not scanned and therefore impossible to evaluate. Additional answer booklets should be used for this reason.

There were some candidates who do not follow the command term of the question and often overwrite their answer wasting valuable time, e.g. question 2a where students are required to list their responses. Candidates struggled in the questions where the application of a definition or concept or evaluation was required (e.g. 5d, 6d, 7c).

In Section B question 5 was selected most commonly by candidates despite the fact that, overall, responses to questions 5b, 5c, and 5d were poorly explained. The candidates should be encouraged to use the 5 minutes of reading time at the beginning of the exam to review questions from Section B carefully. The candidates should choose the question where their knowledge would likely yield the highest total marks and not the top mark in only one of the questions. Question 7 was chosen the least.

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

- The ethical importance of using PAR-Q in study design
- Understanding of specific methods of monitoring exercise intensity
- Analysis of movements at different synovial joints
- The process of beta oxidation
- Definition and application of transfer
- Evaluation of submaximal test
- Mechanics of breathing were often confused with the process of gaseous exchange
- Application of the energy systems during different physical activities
- Characteristics of type IIb muscle fibres in conjunction with how the specific characteristics would specifically benefit a sprinter
- Rehearsal and organization and their use in memory improvement
- Evaluation of the body composition fitness tests containing the strengths and weaknesses
- Application of the Newton's Laws of motion
- Blood distribution during maximal exercise
- Connection between VO_2 max and the use of muscles in cycling versus arm ergometry
- Sliding filament theory
- Recognition of the correct fitness tests for body composition
- Skill continua

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

- Data-based questions
- Safety benefits of use of PAR-Q in study design
- Adaptations of the cardiovascular system to endurance exercise
- Storage location of fat
- Function of ligaments
- Variability of VO_2 max with modes of exercise
- Recall of assessing body composition
- How glucose forms a polysaccharide through a condensation reaction
- Cardiovascular drift
- Recall of Newton's laws

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

1a   Overall, this question was answered very well.

1b   Overall, this was answered very well.

1c   Overall, candidates tended to 'analyse' or 'interpret' rather than 'discuss' which resulted in low scores on this question. Most candidates correctly identified the relationship between the two variables but did not review its meaning.

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1d   Overall many candidates were able to identify the safety implications; however very few candidates referred to the ethical requirements.

1e   Overall, this question was answered very well.

1fi   Overall, this question was answered very well.

1fii   Overall, this question was answered very well.

1g   Overall, this question was answered very well with most candidates taking care to meet the command term. Weaker candidates often said "increased VO_2 max" whereas stronger candidates often were more detailed in their responses.

1h   Overall, this question was answered well; however, some candidates lacked the connection between the use of VO_2 max and the use of muscles earning only partial marks.

2a   Overall, this question was answered very well; however, some candidates used more words than necessary in their answer.

2b   Overall, this question was answered well. A confusion with functions of a tendon happened occasionally.

2ci   Overall, the quality of answers to this question varied widely. Some candidates did not focus on monitoring exercise intensity (as laid out in the course guide) and used a common sense response which was not awarded marks, i.e. "Heart Rate", which is too vague.

2cii   Overall, the quality of answers to this question varied widely. Some candidates were only able to achieve one mark, which typically was awarded for recognition of abduction. Many candidates identified incorrect muscles or did not identify which muscles were agonistic or antagonistic. Candidates often referred to the state of muscles while at Position B rather than the movement from Position A to B.

3a   Overall, this question was mostly answered well; however, there was some confusion with the storage site of glucose or glycogen.

3b   Overall, this question was typically answered poorly. Many candidates were able to recall that ATP is produced through beta oxidation of fatty acids. However very few candidates were able to outline the how ATP is produced through beta oxidation (i.e. conversion of fatty acids to acetyl-CoA and the role of the Kreb's cycle).

4ai   Overall, the quality of answers to this question varied widely. Candidates should be encouraged to be precise and succinct in their definitions.

4aii   Overall, the quality of answers to this question varied widely. Many candidates were able to identify an appropriate transfer; however, few candidates were able to outline how the type of transfer applied to the specific case examples provided by the image and the question (i.e. from long jump to triple jump).

4b   Overall, the quality of answers to this question varied widely. Many candidates provided an example of a test and evaluated that specific test but did not evaluate submaximal tests in general as the question requires. Many candidates referred to the repeatability of submaximal tests which was too vague for a mark. Candidates need to link the concepts of repeatability to the second mark point concerning how maximal tests are not suitable to the entire population.

5a   Overall, this was a very popular and well answered question. Candidates who struggled with this question failed to provide appropriate examples for physical activities particularly with regards to appendicular skeleton.

5b   Overall, this question was answered more poorly than anticipated because candidates did not answer about the mechanics of inspiration, but rather, about the causes of laboured breathing, energy systems, the mechanics of gaseous exchange, or blood distribution, and therefore and missed the focus of the question. A very limited number of candidates identified that accessory muscles are used during maximal exercise or final stages a race.

5c   Overall, candidates did not appear to be well prepared for this question. Candidates were able to provide simple comments regarding intensity. However, many candidates focused on how ATP is produced during each energy as opposed to the contribution of each system to different types of exercise over the course of a match. Often the concept of all three energy systems working at the same time was not explicitly stated by candidates.

5d   There was a large variety of answers to this question. Overall, candidates identified a few of the main characteristics of type IIb fibres but many failed to connect characteristics with enhanced performance of a sprinter. Both concepts were needed in order to be awarded many of the individual mark points. Confusion with type I muscle fibres was common.

6a   This was one of the best responses to this type of question and candidates were clearly well prepared for this type of question.

6b   Many candidates were well prepared for this question and answered it very well; however, several candidates wrote much more than was required for a 4-mark question wasting valuable time that could have been used elsewhere. Candidates were able to describe the sequence of events accurately, but some responses lacked specificity of the steps that were required to earn full marks.

6c   Overall, this question was typically answered very poorly. Candidates struggled to provide enough detail to achieve full mark points. Answers were not focused and candidates did not appear to be prepared for this question.

6d   Overall, this question was answered well. Some candidates struggled to identify the correct fitness tests, confused tests, or described the mechanics of the tests rather than evaluated them.

7a   Candidates struggled to achieve full marks for this question.

7b   This question was generally answered well, although some students were clearly unfamiliar with the concepts of skill profiles. Candidates are encouraged to use a t-chart to

answer the question as it makes it easier for the candidates to organize their thoughts and for the examiners to clearly see and gauge the quality of candidate responses.

7c   Overall, many candidates accurately defined at least one of the Newton's three laws, yet struggled to explain the application of the laws to the situation, missing out on valuable marks. Overall Newton's third law was applied the best, with many candidates struggling to appropriately apply the second law. Commonly there was also a confusion in the application of the first and second law.

7d   Overall the stronger candidates were able to outline the overall amount of blood distributed to the working muscles and non-essential tissues during maximal exercise. However very few candidates were able to explain the vascular shunt mechanism and analyse how this was achieved. The weaker student responses contained many physiological contradictions.

Recommendations and guidance for the teaching of future candidates

- Pay attention to command terms, with particular focus on the objective 3 command terms that require application of definitions and concepts
- Integrate approach across the content covered in the guide
- Consider the ethical importance of using PAR-Q in study design to the theory
- Highlight the specific methods of monitoring exercise intensity
- Integrate analysis of movements at different synovial joints
- Deeper explanation/understanding of beta oxidation
- Definition and application of transfer
- Evaluation of submaximal test
- Mechanics of breathing
- Application of the energy systems during different physical activities
- Understand how specific characteristics of muscle fibres benefit a variety of athletes
- Tools to use in memory improvement
- Evaluation of fitness tests (include both strengths and weaknesses)
- Classifications of motor skill profiles versus skill types
- Application of the Newton's Laws of motion
- Blood distribution during maximal exercise
- Asking for support from other science teachers for in-depth understanding (i.e. physics, biology)

Standard level paper three

Component grade boundaries

Grade:	1	2	3	4	5	6	7
Mark range:	0 - 7	8 - 14	15 - 18	19 - 23	24 - 27	28 - 32	33 - 40

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General comments

- Very few blank questions which is good
- No candidates answering more than 2 options
- Hand writing at times can be an issue
- Some need to ensure that they respond to the command term being used e.g. calculate, compare and contrast
- Generally very good at using the extra pages for their responses but some are writing outside the box and this risks being missed by an examiner

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

- Gaining full marks with explaining how the macrocycle training can avoid overtraining.
- Understanding that the placebo effect is where a subject actually responds positively to a substance that has no active ingredients
- Describing the locus of stability and causality
- Getting full marks outlining ethical issues associated with the measurement of personality
- Understanding the relationship between personality and success
- Outline the World Health Organisation recommendations for physical activity
- Gaining full marks for explaining why a lack of calcium is a major risk factor for osteoporosis
- Gaining full marks for comparing and contrasting water distribution in athletes and inactive individuals
- Describing strategies for increasing muscle glycogen

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

- Answering the data questions. Most candidates are showing the full calculation and not just the answer
- Explaining the effects of adaptations to acclimatization
- Discussing why banned pharmacological substances should not be used.
- Somatic anxiety symptoms
- Defining hypokinetic disease
- The relationship between societal changes and hypokinetic disease
- Analysing type 2 diabetes
- The absorption of amino acids in the intestinal lumen
- Extracellular fluid
- How antidiuretic hormone helps conserve water

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

Option A

1a, b Generally well done.

1c   The command term with this question makes it quite complex to answer.

2a   Students generally answered this well but a deeper understanding about how the evaporation and change of sweat from liquid to gas uses the body's heat and that this cools the body down.

2b   The difficult part to this question is that it asks for the effects of the adaptation to be explained.

3a   Generally done well.

3b   Few candidates were able to get full marks. The parts to the macrocycle are known the difficult thing was then to explain how it can help reduce overtraining.

4a   Most candidates understood that the placebo effect was a about the belief that a substance will help performance but they did not always understand that it actually does positively affect performance. Few candidates made reference to experimental design (control groups), which is really the main use of placebos.

4b   Answered well overall.

Option B

5a, b Done well.

5c   Most focused their answers purely on intrinsic motivation; some tried to link it to extrinsic motivation. It is important to focus on the question being asked.

6   this was a question which many struggled with.

7a, b Poorly answered. Some misunderstood 7b to be about need achievement theory. Generally, I think there is significant confusion over the personality section of the curriculum.

8a   A well understood area.

8b   Many answered this well but some were unable to specify specific emotions and wrote in very general terms. Candidates need to recognise when the question uses a high-level command term and requires a more in-depth response.

9   This was variable in the way students answered. Some students achieved fewer marks because they failed to provide examples.

Option C

10a, b, c All done very well.

11a Done well; at times confused with poor diet.

11b Done well overall; one of the errors was again discussing fast food as a societal change but not connecting that fact that the ease of food without the effort of preparation is the issue in this case.

12a Generally done well – sometimes the hormones involved were mixed up.

12b This was understood very well.

13   Not well understood.

14   Very few recognised that almost all of calcium is stored in the bones and that is why a lack dietary calcium can lead to osteoporosis. It's a key mark point that almost all missed.

Option D

15a Done well.

15b Some did not indicate the nature of the change, i.e. that it was a decrease.

15c This was a complex question and a large number of candidates managed to pick up that VO_2 and peak power relative to weight did increase which improved performance.

16   Generally done well.

17a Also done well overall.

17b Was challenging because it was worth four marks. The command term is demanding and requires some points to be about similarities and differences. In this case the difficult last point was the similarity.

17c The responses to this were mixed where some candidates connected the hormone to affecting sweating rather than having an effect on the kidney.

18   It was surprising how many could not explain carbohydrate loading effectively. Very few recognised the exhaustive training needed to deplete stores first.

Recommendations and guidance for the teaching of future candidates

- Carefully read the question to ensure that the intent of the question is clearly known
- Learn the command terms and consider how they need to be answered
- Check the marks that are allocated to the question and ensure that your response has the same number or more points

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- Many students used the additional workbooks much more effectively. However, some students were still writing outside of the boxes, which made it difficult for the examiners to read
- Candidates must 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

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