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Quantitative Trait Loci (Qtl) Analysis Of Sulfur Sensitivity In Vitis Aestivalis-Derived 'Norton'

Logan Michael Duncan

QUANTITATIVE TRAIT LOCI (QTL) ANALYSIS OF SULFUR SENSITIVITY IN *VITIS AESTIVALIS*-DERIVED 'NORTON'

A Masters Thesis

Presented to

The Graduate College of

Missouri State University

In Partial Fulfillment

Of the Requirements for the Degree

Master of Science, Plant Science

By

Logan Michael Duncan

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Agriculture

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ABSTRACT

The grape and wine industry relies heavily on sulfur and sulfur containing compounds to control the fungal disease powdery mildew (PM). Sulfur dioxide induces large-scale transcriptomic modification in the Eurasian grape species *Vitis vinifera* with little to no phytotoxicity. However, genetic factors contributing to sulfur sensitivity, characterized by vegetative necrosis and defoliation, remain undefined in North American grape species and their commercial hybrids. A mapping population, consisting of 147 F_1 genotypes, was created by crossing *V. aestivalis*-derived 'Norton' and *V. vinifera* 'Cabernet Sauvignon' to identify the genetic basis for sulfur sensitivity in North American wine grapes. Clonally propagated F_1 genotypes were fumigated with sulfur burners under greenhouse conditions. Association and linkage mapping were conducted using single nucleotide polymorphisms (SNPs) and simple sequence repeat (SSR) markers, respectively. A major quantitative trait loci (QTL) for sulfur sensitivity was detected on linkage group 14 (LOD=15). Identification of this QTL will allow future grape breeding programs produce commercially suitable hybrids, which do not display sulfur sensitivity, via marker assisted selection (MAS).

KEYWORDS: sulfur metabolism, sulfur sensitivity, marker assisted selection (MAS), oxidative stress, redox

This abstract is approved as to form and content

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Chairperson, Advisory Committee
Missouri State University

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Approved:

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INTRODUCTION

Genetic Markers

A gene is the most basic unit of inheritance. Alternative forms of a gene are known as alleles. Monogenic traits are controlled by alleles at a specific location on a chromosome, known as a locus. Traits controlled by more than one locus (plural loci) are referred to as polygenic traits. Plant breeding relies on the identification of these trait loci and allelic variants for the purpose of selecting novel traits which improve the marketability and/or performance of a crop (Sleper and Poehlman, 2006).

Trait loci and allelic variants are identified by using genetic markers. There are three classes of genetic markers: morphological, biochemical, and molecular (Collard *et al*. 2005). Morphological markers are observable or "phenotypic" in nature. Morphological markers might also be known as classical markers, because they were the first of the three marker types used in breeding and construction of linkage maps. Biochemical markers are known as isozymes, which are alternative forms of a protein or enzyme. Molecular markers are identifiable variations within DNA, and are the most common type of genetic marker used today. Two types of molecular markers are simple sequence repeats (SSRs) and single nucleotide polymorphisms (SNPs).

The concepts of genetic linkage and segregation are required to identify trait loci. Linkage is calculated by the number of observed cross-over events, occurring between two points on a chromosome, within a population (Vienne, 2003). Cross-over is a biological process which promotes the conservation of functional alleles and elimination of null alleles. Cross-over occurs during meiosis (cell division leading to the production of gametes), when homologous chromosomes align during synapsis and exchange chromosomal segments (Sleper and Poehlman, 2006). Two points on a chromosome are said to segregate if cross-over occurs between them, and the resulting offspring is known as a recombinant.

Simple sequence repeats (SSRs), tandem repeats, or microsatellites are two to five nucleotides, which repeat five to fifty times. SSR markers are very informative due to their high degree of polymorphism and observable size. Another positive attribute is the transferability of this marker between populations and species. Alternatively, large amounts of time are required to design primers, and to sequence an entire population. Additionally, polyacrylamide electrophoresis is required, making it somewhat expensive (Collard *et al.* 2005).

Single nucleotide polymorphisms (SNPs) are just that, a substitution of a single nucleotide within a sequence. SNPs are extremely common, allowing for the construction of highly saturated maps and fine mapping. Next-generation-sequencing allows for entire populations to be quickly sequenced (Collard *et al.* 2005).

Mapping Populations

When creating a population, it is important to find parents with traits relevant for improving production or marketability of that crop species (Sleper and Poehlman, 2006).

It is also important to select cultivars which are complimentary, in the sense that a trait found in one parent is not found in the other; this allows traits to segregate in subsequent generations. Large segregating populations (50-250 individuals) are required for QTL mapping (Collard *et al.* 2005). Having more individuals in a population increases the total number of cross overs on a chromosome, allowing for fine mapping.

Genetic Resources in Grapes

The utilization and manipulation of germplasm resources, within the grape and wine industry, is necessarily complex. The simplest explanation, for this necessity, is that the cultivation of grapes originated in Europe where the native species (*Vitis vinifera*) evolved mostly sheltered from disease, pests, and large fluctuations in seasonal temperatures. Evolving in a sheltered environment dramatically decreased the natural adaptability of this species, to the point that it nearly went extinct in the late-1800s, due to the introduction of phylloxera from North America.

The *Vitis aestivalis*-derived 'Norton' is the state grape of Missouri. It was developed by Dr. Daniel Norborne Norton of Richmond, Virginia, sometime in the 1820s (Ambers, 2013). Norton is widely grown throughout the Midwest due to its good disease resistance (Cornell Cooperative Extension, 1991). Some characteristics such as its high vegetative vigor, seed tannins, small cluster size, and poor color in hot years cause Norton to produce wine that is below premium quality (Jogaiah *et al.* 2013). Additionally Norton is known to be highly sensitive to sulfur sprays, making it difficult to grow in the field near plants requiring sulfur spray, or greenhouse conditions where sulfur burners are used (Cornell Cooperative Extension, 1991). Most of these positive and negative traits are believed to originate from wild *V. aestivalis* which is said to contribute to the paternal lineage of Norton (Ambers, 2013)

Vitis vinifera 'Cabernet Sauvignon' produces excellent quality wine making it one of the most popular cultivars in the world. Cabernet Sauvignon is one of the most vigorous, disease resistant and cold tolerant cultivars of the *V. vinifera* species, however, it is still inadequate for Midwestern conditions. It is susceptible to downy mildew, powdery mildew, phomopsis, phylloxera, crown gall, botrytis berry bunch rot, very susceptible to eutypa die-back, botryosphaeria dieback and esca. Cold tolerant down to -5 °F (eXtension, 2012).

Sulfur Sensitivity in Grapes

Sulfur is reported, by Homer, to have been in uses as a fungicide over 3,000 years ago, "the pest-averting sulfur with its properties of divine and purifying fumigation" (Williams and Cooper, 2004). Sulfur can be applied in elemental form via powders and colloidal sprays, or in a gaseous state as sulfur dioxide (Williams and Cooper, 2004), (Sessions, 1936). It was assumed for many years that sulfur acted alone in preventing disease, such as powdery mildew, by non-selectively denaturizing pathogen proteins (Sessions, 1936). Recent studies, however, have demonstrated sulfur to play a dynamic role in plant defense against pathogens. Sulfur induced resistance has now been documented in several organisms (Williams and Cooper, 2004), and is attributed to metabolic defense pathways involved in sulfur detoxification (Giraud et al. 2012), (Romero et al. 2014) through conditionally expressed transcriptomic modifications (Noctor et al. 2002), (Bernardi et al. 2001). The exact pathways and initiation factors for sulfur induced resistance remain elusive, as sulfur detoxification and assimilation processes interact with enzymes, cell wall proteins, lipids, sugars, nucleic acids, a range of secondary metabolites, phytohormones and other regulatory chemicals (Giraud et al. 2012).

Sulfur dioxide enters leaves through stomatal pores, and accumulates in the apoplast where it combines with water to form sulfites. This reaction ($SO_2 + H_2O = 2H^+ +$

SO_3^{2-}) dehydrates the cell and reduces pH of the apoplast. Reactive oxygen species are produced in response to this reaction. Dehydration responsive protein (RD22) along with ten glutathione S-transferase (GST) orthologues were up regulated in grape berries exposed to sulfur dioxide (Giraud et al. 2012). GSTs are known to act as glutathione peroxidases to scavenge H_2O_2 and fatty acid hydroperoxides potentially mitigating damage cause by ROS and superoxides (Shahrtash, 2013).

Sulfite is highly reactive and able to penetrate cell membranes so it is critical for the plant to metabolize sulfur to a stable state. There are two pathways for the reduction of SO_3^{2-} which require energy, and two pathways for the oxidation of SO_3^{2-} which don't require energy, but produce reactive oxygen species (ROS) (Giraud et al. 2012), (Saito, 2004).

The first reduction pathway takes place in the chloroplast, and requires the enzyme sulfate reductase (SiR). Sulfite is transformed to sulfide. Sulfide then reacts with O-acetylserine (OAS), catalyzed by O-acetylserinethiol-layse (OASTL), to form cysteine. The second reduction pathway takes place in the chloroplast where sulfite combines with uridinediphosphate-glucose (UDP-glu) and UDP-sulfoquinovose synthase to form UPD-6-sufoquinovose. The first oxidation reaction occurs when sulfite reacts with sulfite oxygenase (SiO) to form sulfate and a reactive oxygen species (ROS).The second oxidation reaction occurs when sulfite reacts with a ROS to form sulfate.

It is unknown what causes transcriptome reprograming, drought/turgor stress, free radicals, degradation of cell membranes etc. (Giraud et al. 2012), (Bernardi et al. 2001), (Vince and Zoltan, 2011). These unknowns highlight the need for further study.

METHODS

Population Establishment and Genotypic Data Collection

A first filial test-cross population was constructed using *V. aestivalis*-derived 'Norton' as the maternal/seedbearing parent, and *V. vinifera* 'Cabernet Sauvignon' as the paternal/pollen-donor parent. A total of 74 individual F_1 offspring were produced via controlled pollination in May of 2004, and germinated the following spring under the direction of Dr. Wenping Qui. An additional 182 individual F_1 offspring were produced using the same techniques in May of 2010, and germinated the following spring under the direction of Dr. Chin-Feng Hwang.

Cabernet Sauvignon was grown in field and greenhouse conditions to extend the availability of pollen to ensure that crosses could be made. Flower clusters were collected from Cabernet Sauvignon one to four days' prior the expected pollination date, when they are between the 21^{st} and 25^{th} E-L growth stage, 30% to 80% percent cap fall, respectively (Coombe, 1995). Clusters were placed in trays, under incandescent lamps, and allowed to dry overnight. Dried clusters were lightly tapped over trays, and loose pollen was then funneled into 50mL Falcon tubes.

Needle nose tweezers were used to emasculate Norton flower cluster between the 19^{th} and 21^{st} Eichhorn Lorennz (E-L) growth stage. The 19^{th} stage is defined as the start of flowering when flower caps begin to loosen, the 20^{th} stage is defined as ten percent of caps off, and the 21^{st} stage defined as thirty percent of caps off (Coombe, 1995). Emasculation was conducted under calm weather conditions, between 6:00 and 10:00

a.m., when pollen drift was low; to minimize undesirable open-pollinations and self-pollinations.

Individual flowers with missing caps were removed from the clusters, as they had already been exposed to pollen. Flower caps and anthers were removed from the remaining flowers systematically, starting at the proximal end of the cluster (rachis) and working down, to avoid mechanical damage to exposed stigma. Fully emasculated clusters were covered with a brown paper bag, tied around the cane and rachis.

New paper bags were labeled with the name of the male pollinator and date prior to pollination. Pollination was preformed 12 to 36 hours post emasculation. The original brown paper bags were removed, the clusters lightly dusted with pollen using a paint brush, and then recovered using a labeled bag. Plastic ribbons were cut to three feet in length, and tied above the cluster to aid in fall berry retrieval.

Marked berry clusters were collected a week before commercial harvest to ensure that seeds were fully ripe, and that clusters wouldn't be mistakenly picked for wine production. Clusters were taken directly to the lab, and seeds were removed by hand. Seeds were put into a 500 mL beaker along with approximately 300 mL H_2O, allowing immature seeds to float on the surface for easy separation and removal. Remaining fully matured seeds were rinsed and placed on paper towels and allowed to air dry for 14 days. Seeds were placed in marked paper envelopes for storage once fully dried.

Seeds were stratified in damp sand, in one-quart plastic bags, approximately three months before planting. Stratified seeds were stored at 4°C. Seeds were separated from the sand using a sieve. Seeds were then planted in germination trays and place into greenhouse conditions.

DNA was extracted from leaf samples of potential hybrids using Quiagen DNeasy® Kits. Purified DNA was stored at -20°C. True hybrid identification was performed using five SSR makers which were identified to be polymorphic/heterozygous in both parents. Sample DNA, dNTPs, Taq polymerase, fluorescent dye, Mg++, and buffer were combined with primer pairs for five SSR markers identified to be polymorphic/heterozygous in both parents, and amplified using a thermocycler. Amplicons were run through capillary array electrophoresis to identify allele length of selected loci. Potential hybrids with one allele, from each parent, at each loci were confirmed true hybrids; potential hybrids not meeting these criteria were discarded.

Confirmed true hybrids were screened at 373 SSR marker sites using protocol identical to that for true hybrid identification. Leaf samples for all 2005 progeny and 90 of the 2011 progeny were sent to Cornell University through the VitisGen Program. Next Generation Sequencing was used to identify 43,700 SNP sites for each F_1 individual.

Generating Phenotypic Data

On June 24, 2015 six green wood cuttings were collected from 147 F_1 progeny, and twelve green wood cuttings were collected from each parent. Cuttings were tagged with their genotype number, pruned to a length of 10 centimeters, and leaves from the bottom axillary node were removed. Canes were then dipped in Hormodin 0.1% IBA rooting hormone, and inserted into 40/80 QPlugs manufactured by International Horticultural Technologies. QPlug trays were placed under aerial misters, in greenhouse conditions, for 21 to 28 days.

Rooted plugs were transferred to six inch pots, and allowed to establish root systems for 8 to 10 weeks. This step was highly dependent on vigor of individual cuttings. Transferring plants in to too large of a pot can cause soil to remain moist for prolonged periods of time, resulting in stunted growth or root rot. Plants were sprayed with insecticidal soap to control aphids.

Plants were organized in the greenhouse according to their genotypic number, which facilitated selection of replicates to be used in the sulfur assay. A total of 576 individual cuttings, representing 146 F_1 genotypes, were conditionally selected for uniformity in plant size. No cuttings with less than five leaves were used. The largest three replications from each genotype were selected in “round 1”. The remaining replicates were selected in “round 2” from largest to smallest, with no basis on genotype.

Number of replicates, to be included for the sulfur analysis, was counted for each genotype. A “test number” from (1 to 576) was assigned to each replicate using a random sequence generator. Plants were tagged with their test number along with the original tags indicating genotype number. Replicates were sorted in ascending order (1 to 576), in tubs of six, with twelve tubs per greenhouse table, with a total of eight greenhouse table.

Literature indicated inconsistencies in sulfur application technique and measurement of sulfur application (Considine and Foyer, 2015). Vaporization was indicated as a common treatment (Bernardi *et al.* 2001), (Williams and Cooper, 2004), (Sessions, 1936) and (Giraud *et al.* 2012). Sulfur burners allow the flexibility required for greenhouse conditions, as they could be used at night when temperatures are lower. Our treatments were carried out with two sulfur burners, with three tablespoons of sulfur each, inside a 1,250 square foot greenhouse (50’ by 25’ by 10’), as per the manufacturers recommendations (Planet Natural, 2015). Two sulfur burners, placed at quartile positions to allow uniform coverage, were used. A quartile is defined as halfway to the middle of the greenhouse, from either side. Burners were turned on at 12:01 a.m. and off at 8:01 a.m. to reduce additional sulfur damage caused by heat in excess of 30 °C. The three tablespoons of sulfur were not burned to completion. Intake/outflow fans were disabled (to reduce dilution of sulfur dioxide at the back of the greenhouse), and circulation fans within the greenhouse were enabled; to homogenize sulfur coverage throughout the greenhouse. The first trial was conducted on September 11th, 2015, the second on September 18th, and the last on September 25th.

Parameters were originally set on a one to four scale, 1- no damage, 2-discoloration, 3-less than 20% of leaf with hypersensitive burn, 4-more than 20% of leaf with hypersensitive burn or leaf drop. It became apparent that some plants had leaf damage not acquired from sulfur. Parameters were redefined by 13 categories; Dead, Dark Vein, Dark Leaf at Petiole Junction, Leaf Curl, Leaf Drop, Small Spots, Collapsed Cells, CHlorotic, Salicylic Acid-like (pre-treatment leaf curl), Black Rot, Downy Mildew, Powdery Mildew, and Disease Damage. Each of the 13 catigories could receive a rank of one to four, 1-no indication, 2-possible indication (hard to differentiate), 3-possitive indication, 4-sever indication.

Each plant was individually photographed before the first treatment, and after the third treatment. Data was collected 48 and 96 hours after each treatment. Primary leaf drop, associated with LD phenotype, occurred around 48 hours after treatments. Secondary leaf drop, not associated with LD phenotype, occurred 96 hours or more after treatments.

Quantitative Trait Loci (QTL) Analysis

A linkage map was constructed using SSR genotypic data for the included genotypes. Marker linkage was determined using JoinMap4.1. Parameters were set for an independence logarithm of odds (LOD), using a regression map algorithm, and Kosambi's map function. Marker linkage statistics, genotypes, and phenotypes were transferred to MAPQTL6 for linkage map construction. Composite interval mapping was used for trait analysis.

Association mapping was conducted in the program TASSEL (Trait Analysis by aSSociation, Evolution, and Linkage). A SNPs data library for our population was loaded into the program. Genotypes not involved in the analysis were filtered out. SNPs site filters were set at a minimum count of 116 of 125 sequences, minimum allele frequency of 0.15, and a maximum allele frequency of 0.85. Once filtered 7,054 SNPs sites remained for trait analysis. A kinship analysis was performed using the SNPs data. Trait values for sulfur sensitivity were loaded into TASSEL. Genotypic and phenotypic data were union joined. Union joined data was then selected with the kinship map to perform mixed model analyses (MLM) and general linear model analyses (GLM).

RESULTS

Parental phenotypes were consistent with previous publications by the Cornell Cooperative Extension (1991). Norton and Cabernet Sauvignon replicates, with the same number, were grown side by side on each of the eight greenhouse tables to make sure sulfur treatment was consistent throughout the greenhouse. To help account for different growth habits or damage cause by diseases photographs were taken for every replication, parents and progeny, before and after sulfur application. Norton (02) and Cabernet Sauvignon (02) both started around the same height, however, the later has a very compact growth habit with more than three times as many leaves (Figure 1)

Sulfur application consistently caused leaf drop (LD), chlorosis (CH), dark leaf at the petiole junction (DLPJ), leaf curl (LC), and a hypersensitive response-like necrosis or collapsed cells (CC) in all Norton replicates (Figures 1 & 2). In addition to leaf damage all Norton replicates became stunted. Alternatively, all Cabernet Sauvignon replicates remained very vigorous (Figure 1). Cabernet Sauvignon did show some damage (Figure 3), but this was attributed to powdery mildew (PM), downy mildew (DM), black rot (BR), and pre-treatment leaf curl (SA).

The F_1 progeny's phenotypes were much harder to evaluate than the parents due to the segregation of disease resistance and sulfur sensitivity. Disease complexes (figures 4 and 5) were identified and quantified to avoid mistakenly attributing disease damage to sulfur sensitivity.

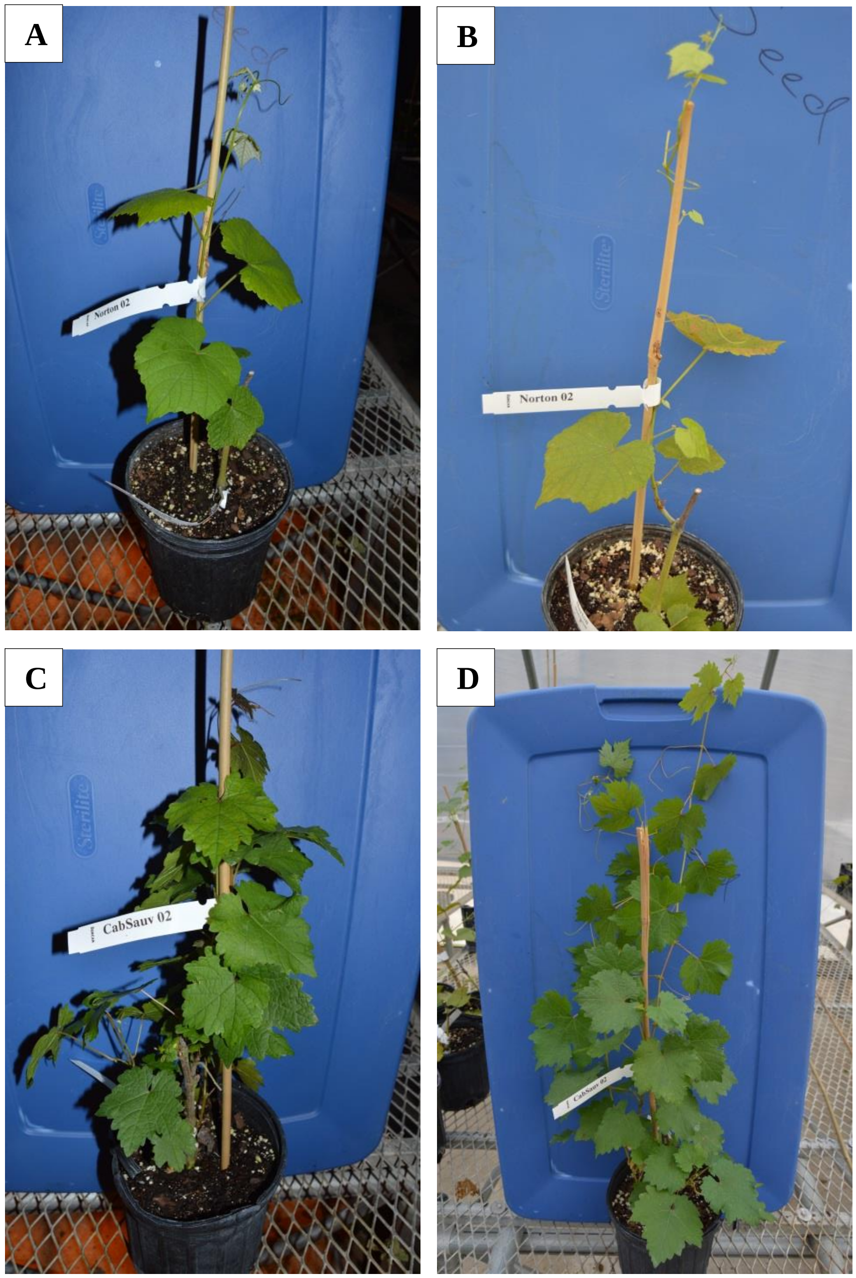

Figure 1. Parents pre-treatment and post-treatment. The female parent Norton (*V. aestivalis*–derived) is shown before (A) and after (B) sulfur application. Cabernet Sauvignon (*V. vinifera*) before (C) and after (D) sulfur application. Parental replicates were grown side by side to ensure consistent sulfur exposure. Stunted growth of the apical meristem, general leaf burn, leaf curl, necrosis, and abscission of immature leaves was observed in Norton (B). Cabernet Sauvignon remained vigorous and healthy throughout the sulfur trial (D).

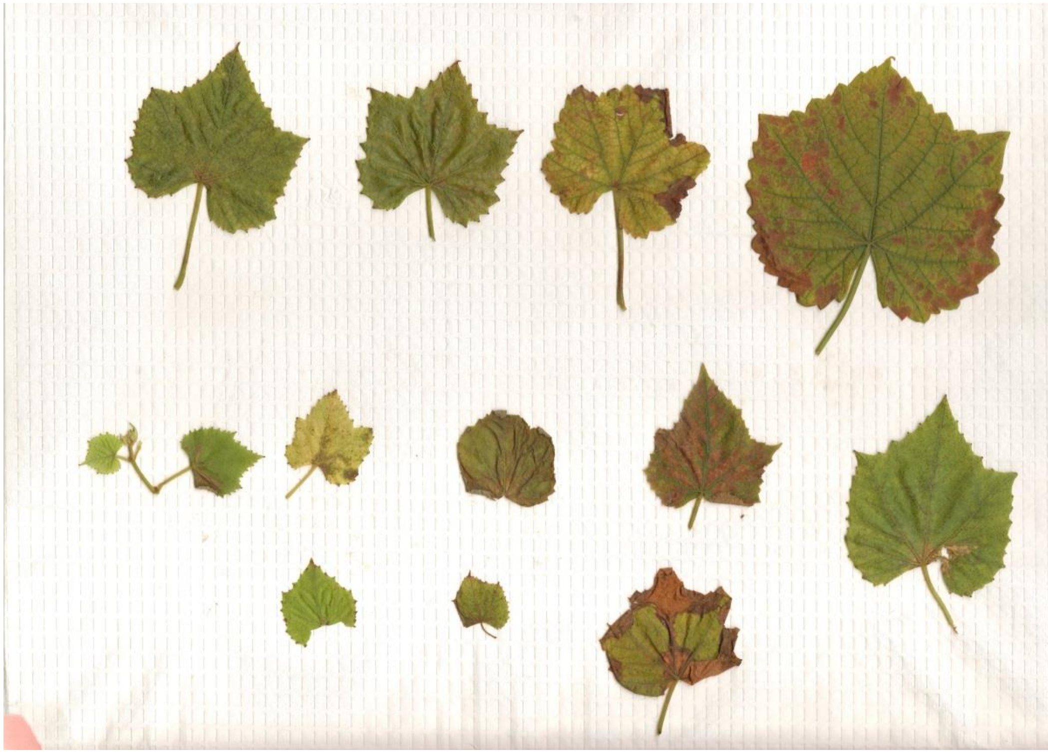

Figure 2. Norton post-treatment leaf collection. These leaves were collected from the eight Norton replicates following the third and final sulfur application. Mature leafs, shown on the top row, generally displayed leaf curl (LC), chlorosis (CH), and necrosis (CC), but not abscission (LD). Immature leaves, shown on the middle and lower rows, displayed all characteristics previously mentioned for mature leaves in addition to leaf drop, dark leaf at the petiole junction (DLPJ), and dark veins (DV).

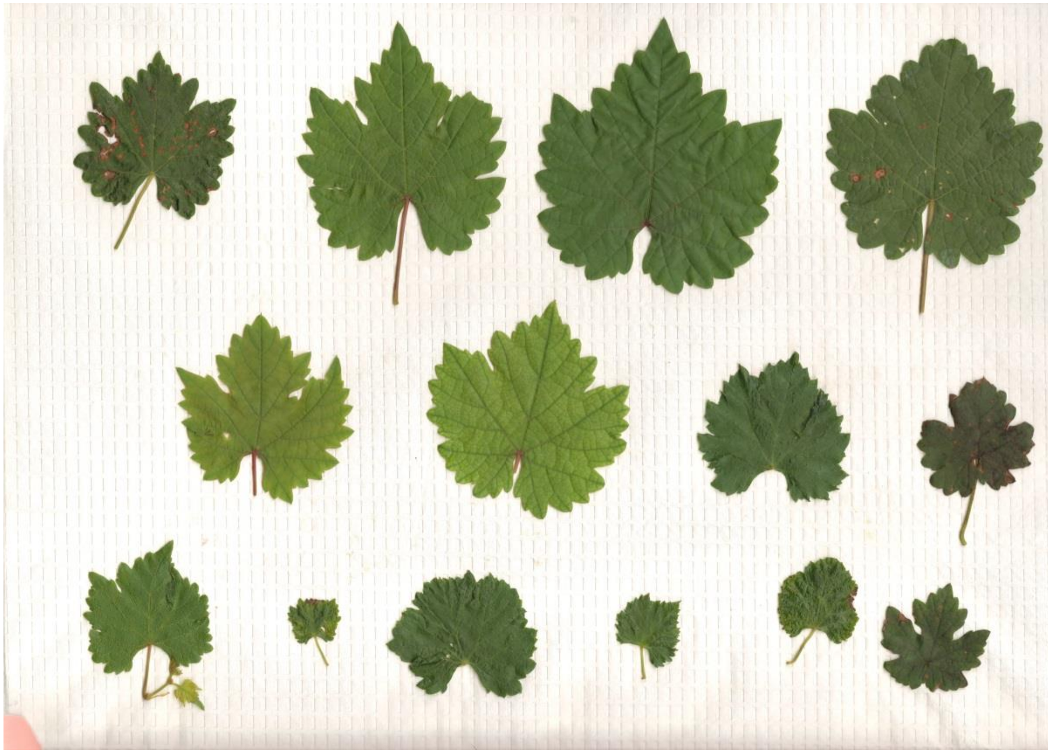

Figure 3. Cabernet Sauvignon post-treatment leaf collection. These leaves were collected from the eight Cabernet Sauvignon replicates following the third and final sulfur application. All leaves were generally green and healthy. Extraneous variables, which could be mistaken for sulfur sensitivity, included powdery mildew (PM), downy mildew (DM), black rot (BR), and pre-treatment leaf curl (SA). Downy mildew symptoms can be seen on the far left and far right leaves on the top row. Black rot can be seen on the far right leaf in the middle row. Pre-treatment leaf curl can be seen on the four middle leaves on the bottom row.

Figure 4. Disease complex of downy mildew (DM) and black rot (BR). All damage was quantified and categorized to avoid false positive and negative error. Above is extensive leaf damage not caused to sulfur sensitivity.

Figure 5. Downy mildew (DM) on backside of leaf. Disease incidence within the greenhouses contributing to extraneous variables.

Sulfur Phenotypes

Segregation was observed for sulfur sensitivity in the F_1 pseudo-testcross population. Raw data for all phenotypes, for all 576 of the F_1 replicates, can be found in the apendix.

The first traits to become observable were primary leaf drop, which occurred 24 to 36 hours after treatment. Leaves from primary leaf drop displayed little to no burns or necrosis, and had an overall green healthy appearace (Figure 6). Some genotypes, in extreme cases, droped all leaves resulting in a dead phenotype (Figure 7). General linear model (GLM) statistacal analysis (Figure 8), conducted in TASSEL, identified SNPs associated with LD on linkage group 14 (LOD=11) and linkage group 19 (LOD=5.5). Figure 9 shows a GLM analysis conducted by comparing sulfur sensitive genotypes with LD to sulfur sensitive genotypes without LD; this could potentially show minor QTLs influencing LD. Figure 9 is meant to show that all analyses are comparative.

Cell collapase (CC) phenotype became apparent around 48 hours and intensified up to 72 hours after treatment, with intervein burning becoming apparent (Figure 10). This phenotype appears very similar to hypersensitive response or programed cell death. Manhattan-plot shows results of GLM analysis for SNPs associated with the cell collapse (CC) phenotype (Figure 11). Suspected QTL for CC on linkage group 14 (LOD=12).

Dark veins and dark leaf at petiole junction phenotypes began expressing 48 to 72 hours after sulfur treatment (Figure 12). Manhattan-plot for GLM analysis of the dark leaf at petiole junction (DLPJ) phenotype is shown, figure 13, with a QTL on linkage group 14 (LOD=6). Figure 14 shows the Manhattan-plot for the GLM analysis for the dark vein (DV) phenotype. Suspected QTL associations for the DV phenotype are on linkage group 14 (LOD=5) and possibly linkage groups 18 and 19 (LOD=3).Leaf curl phenotype was the became apparent 48 to 72 hours after sulfur treatment (Figure 15). QTL for the LC phenotype appears to be on on linkage group 14 (LOD=8.5), (Figure 16).Small spots were also noticed 48 to 72 hours after sulfur treatment (Figure 17), however, it doesn't appear to be correlated with sulfur sensitivity (Figure 18).

The phenotypic values, 1 (no damage) to 4 (sever damage), for LD, CC, DVLJ, and LC were averaged for each genotype; displayed graphically in Figure 19. A GLM analysis was conductd in TASSEL using this composite score, yeilding a LOD=15.5 on linkage group 14 (Figure 20). The composite score was then loaded into Rqtl, which uses composite interval statistical test, to confirm the resuls obtained by TASSEL. The Rqtl analysis resulted in a potential QTL originating from Norton on linkage group 14 with a LOD=16 (Figure 21). A final statistical test was conducted in MAPQTL6 using the composite score, and a linkage map constructed using SSR markers in JoinMap4.1. Results from the CIM analysis conducted in MAPQTL6 showed the reaffermed previous tests with a QTL predicted on linkage group 14, with a LOD=17.5 (Figure 22).

Figure 6. Primary leaf drop (LD) phenotype without necrosis, collapsed cell, or dark vein/leaf/petiole.

Figure 7. Complete defoliation corresponding with the dead (D) phenotype.

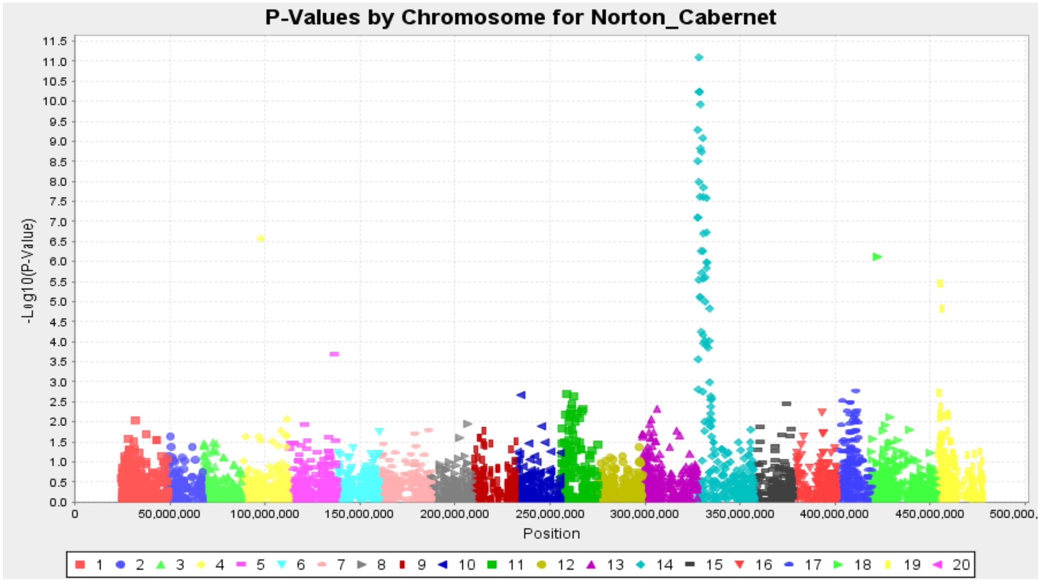

Figure 8. Manhattan-plot for the leaf drop (LD) phenotype. Suspected associations on linkage group 14 (LOD=11) and 19 (LOD=5.5).

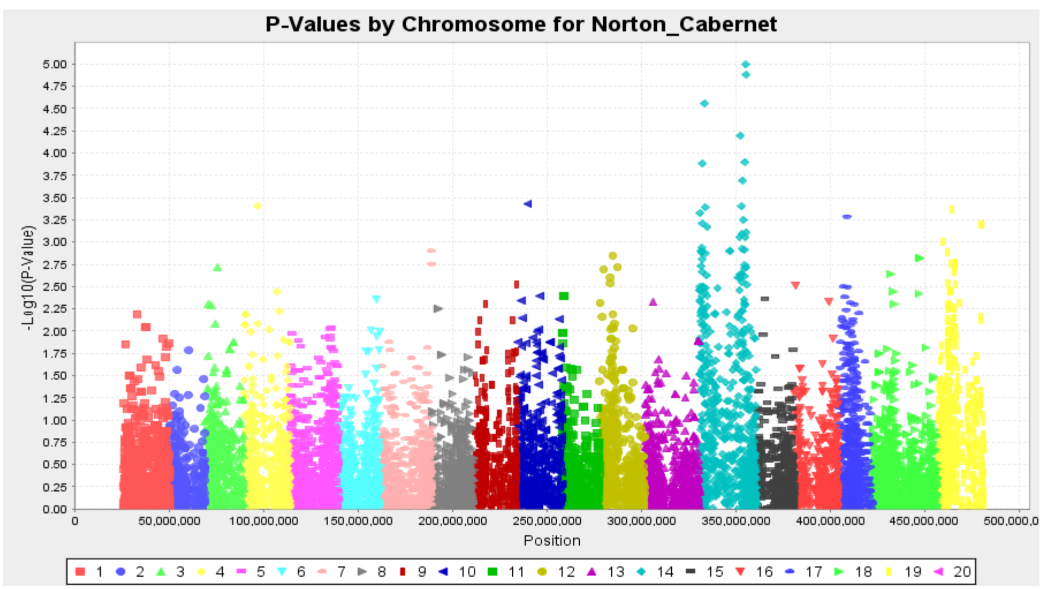

Figure 9. Manhattan-plot for the leaf drop (LD) phenotype, for 66 F_1 individuals suspected to be sulfur sensitive, to show analyses are comparative.

Figure 10. Collapsed cell (CC), hypersensitive response-like, phenotype.

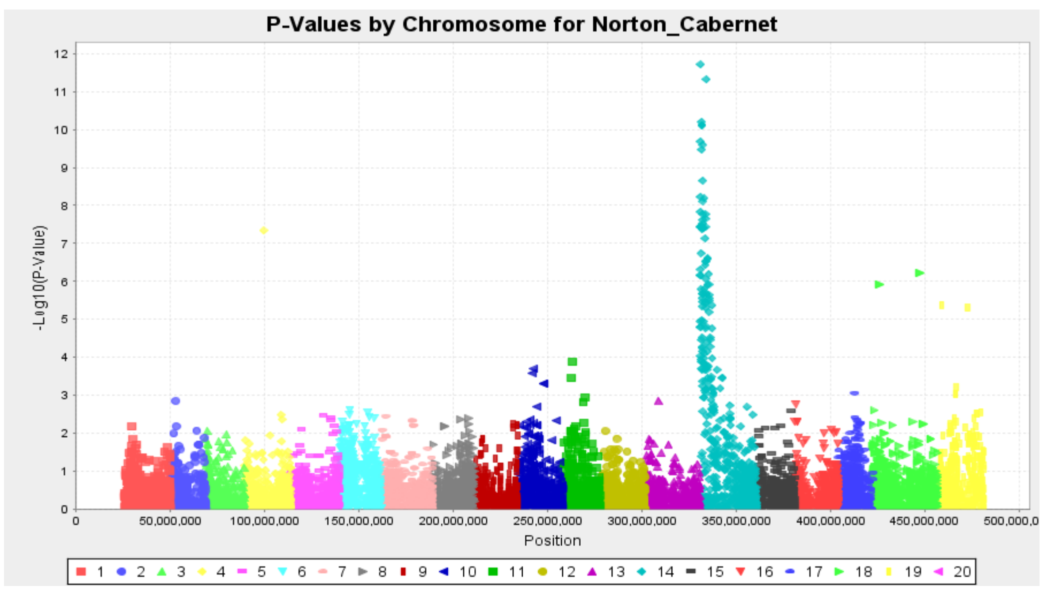

Figure 11. Manhattan-plot for the cell collapse (CC) phenotype. Suspected associations on linkage group 14 (LOD=12).

Figure 12. Dark vein (DV) and dark leaf at petiole junction (DLPJ) phenotype.

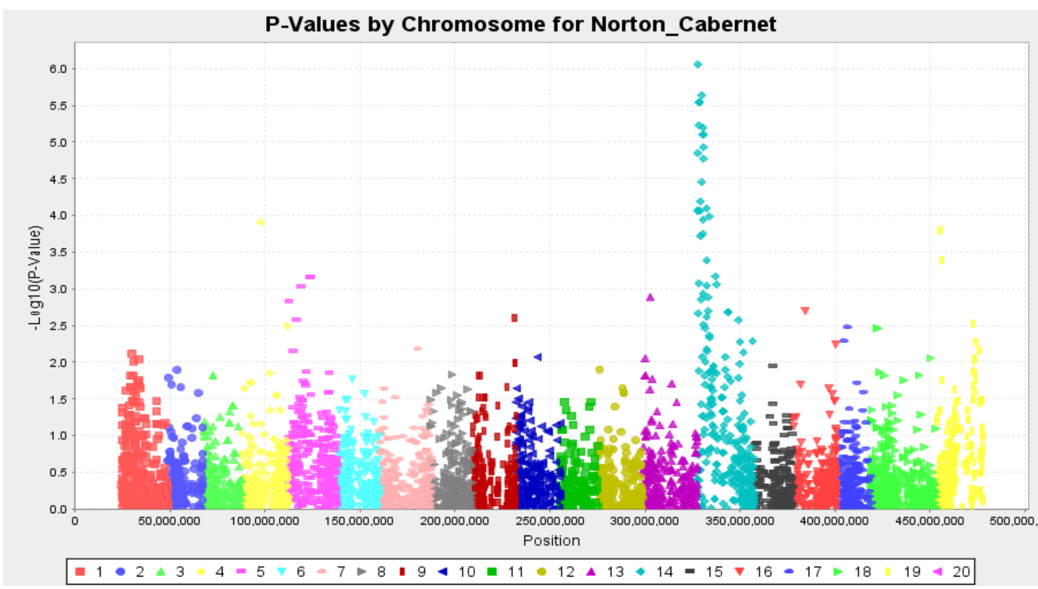

Figure 13. Manhattan-plot for the dark leaf at petiole junction (DLPJ) phenotype. Suspected associations on linkage group 14 (LOD=6).

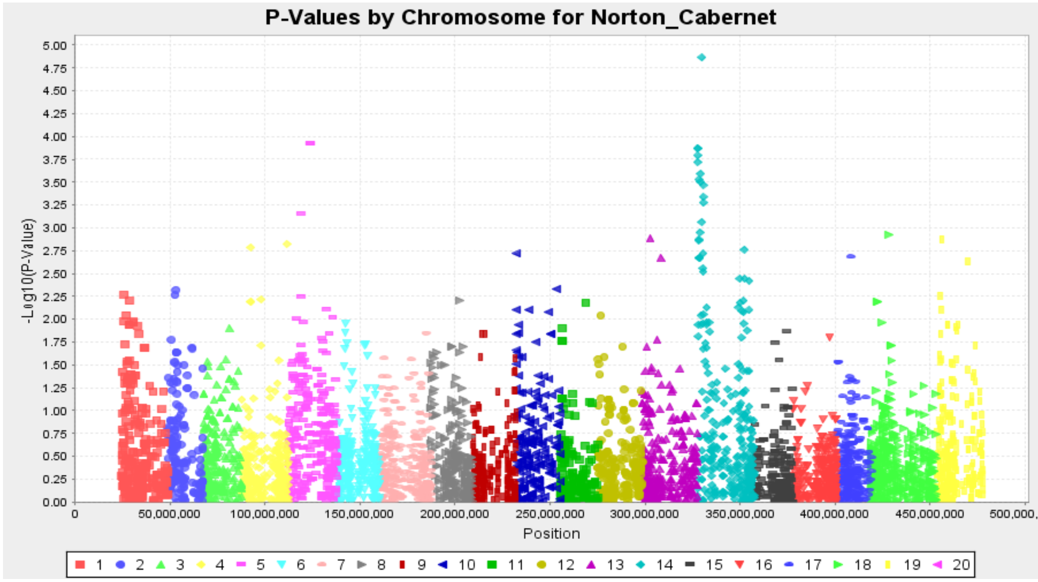

Figure 14. Manhattan-plot for the dark vein (DV) phenotype. Suspected associations on linkage group 14 (LOD=5) and possibly 18 and 19 (LOD=3).

Figure 15. Leaf curl (LC) phenotype.

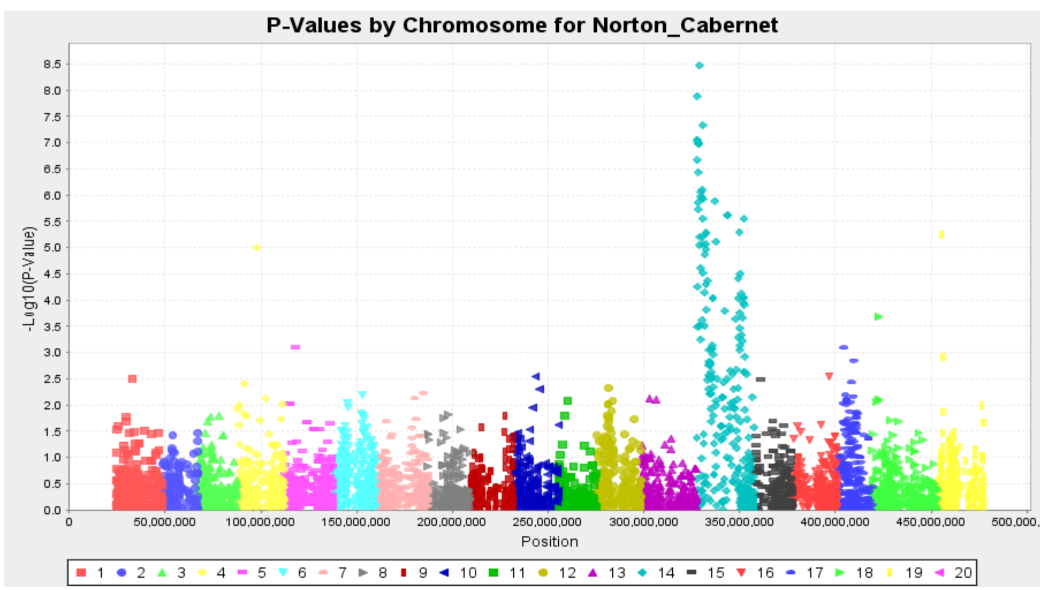

Figure 16. Manhattan-plot for the leaf curl (LC) phenotype. Suspected associations on linkage group 14 (LOD=8.5).

Figure 17. Small spots (SS) phenotype.

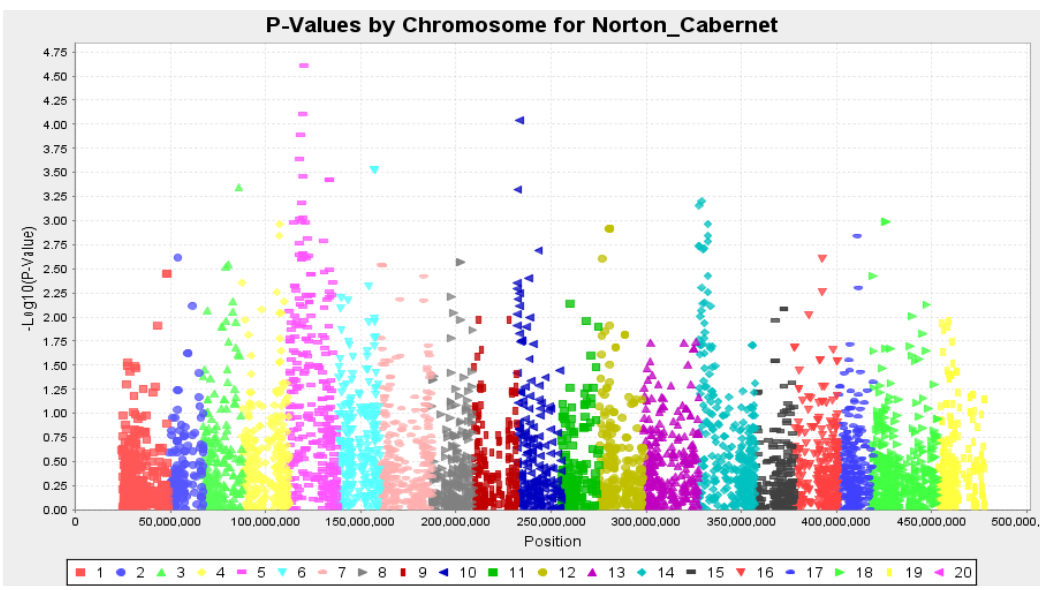

Figure 18. Manhattan-plot for the small spots (SS) phenotype. Not correlated with sulfur sensitivity QTL on linkage group 14.

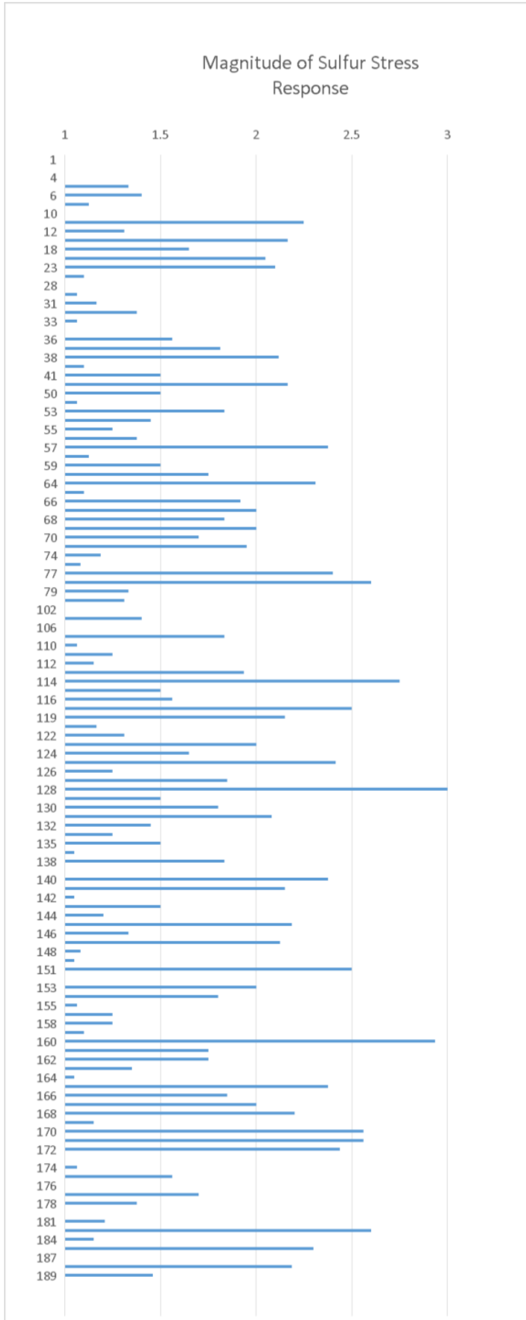

Figure 19. Segregation of stress response in F_1 genotypes. No damage (1) to sever damage (3). Segregation was calculated by averaging DVLJ, LC, CC and LD phenotypes for each genotype.

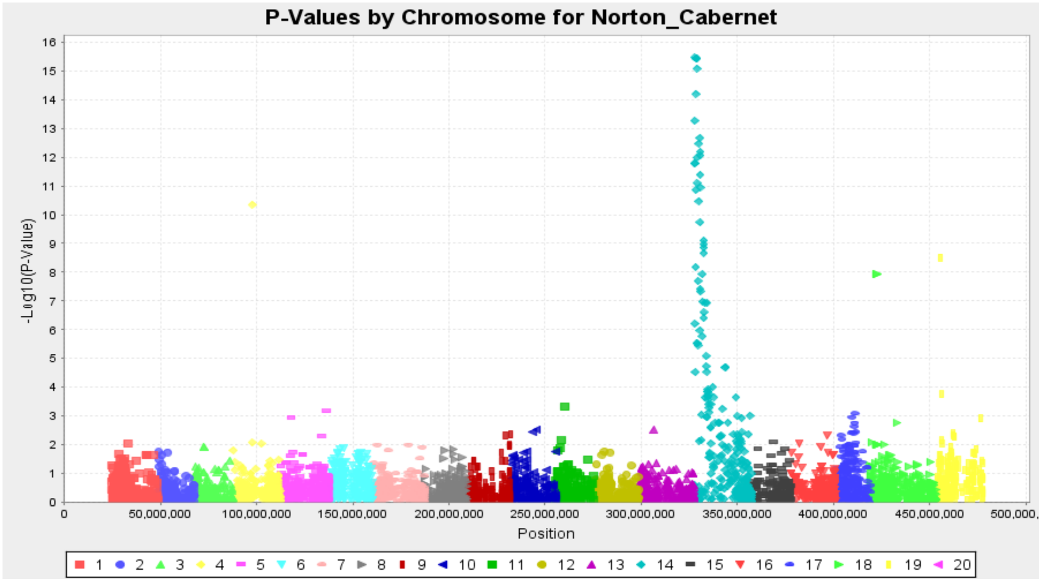

Figure 20. Manhattan plot: composite score for sulfur sensitivity phenotypes. Generated in TASSEL using GLM analysis and the segregation data from Figure 19 resulting in a LOD=15.5 on linkage group 14. Composite score is an average of DVLJ, LC, CC, LD phenotypes for each genotype.

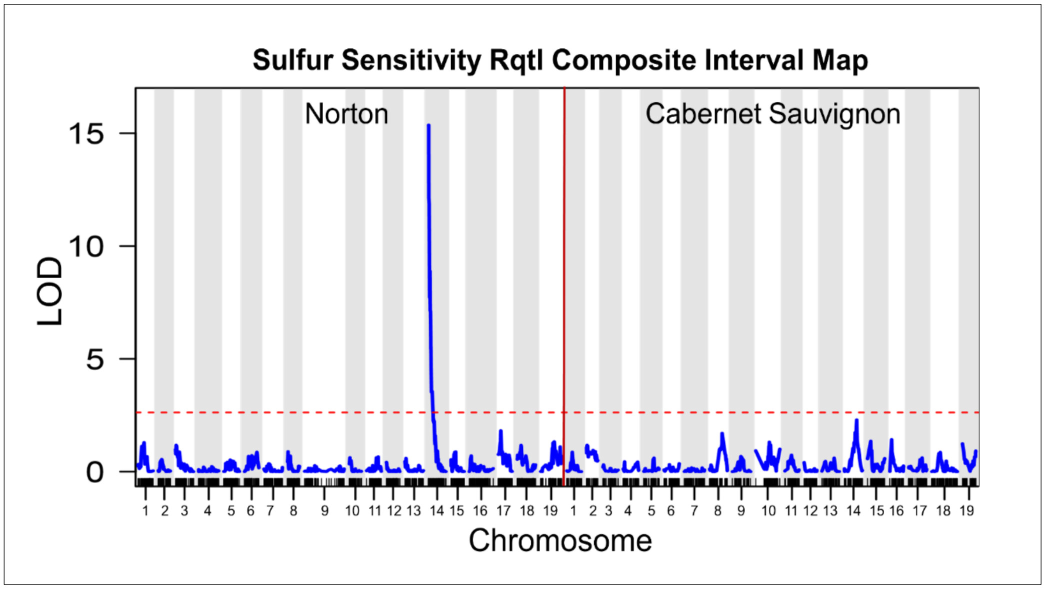

Figure 21. Rqtl composite score for sulfur sensitivity phenotypes. Generated in Rqtl using CIM and the segregation data from Figure 19 resulting in a LOD=16 on linkage group 14; originating from Norton. Composite score is an average of DVLJ, LC, CC, LD phenotypes for each genotype.

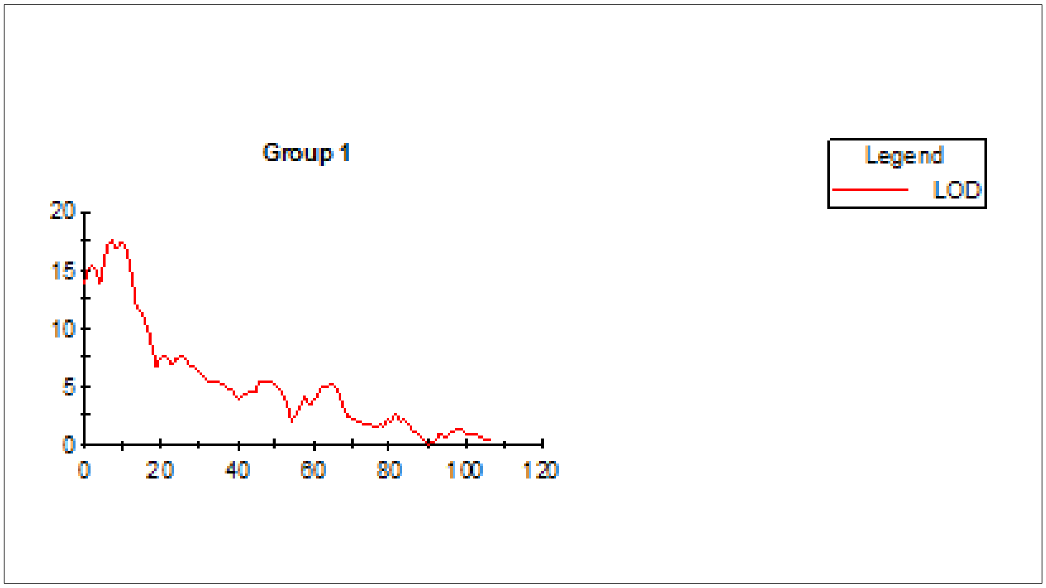

Figure 22. Composite score for sulfur sensitivity phenotypes using SSR markers. JoinMap4.1 was used to construct a linkage map using simple sequent repeat (SSR) markers. Parameters were set for an independence logarithm of odds (LOD), using a regression map algorithm, and Kosambi's map function. Marker linkage statistics, genotypes, and phenotypes were transferred to MAPQTL6 for linkage map construction. Linkage map showed a LOD=17.5 on chromosome 14. Composite interval mapping was used for trait analysis. Composite score is an average of DVLJ, LC, CC, LD phenotypes for each genotype.

DISCUSSION

Results

Our female parent *Vitis aestivalis*-derived 'Norton' displays sulfur sensitivity. Norton is suspected to be 50% *V. aestivalis* (paternal), and 25-50% *Vitis vinifera* and 0-25% *Vitis labrusca* (maternal) (Ambers, 2013). Sulfur sensitivity has been described in other French-American hybrids; allows us to hypothesize sulfur sensitivity is a dominant trait (Cornell Cooperative Extension, 1991). We can hypothesize Norton is heterozygous for sulfur sensitivity based on its parentage.

Our male parent *V. vinifera* 'Cabernet Sauvignon' doesn't display sulfur sensitivity. We can hypothesize that if sulfur sensitivity is a dominant trait, if Norton is heterozygous for that trait, and if Norton is crossed with Cabernet Sauvignon, then sulfur sensitivity should segregate in the resulting pseudo-F_1-testcross in a 50/50 ratio; roughly 50% of the mapping population is expected to be heterozygous sulfur sensitive, and roughly 50% of the mapping population is expected to be homozygous sulfur tolerant.

We wanted to simulate sulfur exposure consistent with industry standards, however, sulfur application methods are inconsistent (Considine and Foyer, 2015). Sulfur spray was determined to be an incompatible method for applications within greenhouse settings, as greenhouses can reach temperatures in excess of 38 °C, and temperatures in excess of 30 °C are known to cause sulfur damage in plants supposedly tolerant to sulfur (McManus, 2013). This damage is attributed to rapid volitization of S^0 to SO_2 which combines with moisture on within the greenhouse, and on the leaf surface to form sulfuric acid.

Clear phenotypic segregation was observed within the F_1 population (Figure 19). Our original phenotypic parameters were inadequate as we expected sulfur sensitive phenotypes to resemble that of Norton, and sulfur tolerant phenotypes to resemble that of Cabernet Sauvignon (Figures 1-3). In reality phenotypes were continuous, and even transgressive of the Norton parent (Figure 7). In addition, there were phenotypes, such as small spots (Figure 17), which didn't correspond with loci when analyzed; the best explanation for this is sulfur dioxide reacting with moisture around the stomata creating sulfuric acid, and causing chemical burns. Leaves were damaged from diseases within the greenhouse as well (Figures 3-5). It was for all of the reasons that new criteria were developed for judging sulfur sensitivity within a breeding population.

The 13 categories (Dead, Dark Vein, Dark Leaf at Petiole Junction, Leaf Curl, Leaf Drop, Small Spots, Collapsed Cells, CHlorotic, Salicylic Acid-like (pre-treatment leaf curl), Black Rot, Downy Mildew, Powdery Mildew, and Disease Damage) were selected so that all damage or leaf characteristic could be attributed to something. With so many phenotypes that simply assigning a number (one to four) was arbitrary; damage incidence needed to be standardized based on the phenotypes. The new phenotypic parameters allowed us to decrease the error accrued by misphenotyping disease related damage as sulfur damage.

The results of the dark vein phenotype, (Figure 14), had the lowest LOD score of the sulfur related phenotypes, which was estimated to be between four and five. This could have been due to the phenotype being hard to identify, or that the phenotype was related to leaf drop. It the latter is true, then it is possible for leaves that displayed the phenotype to fall from the plant before data could be collected. The results of the dark leaf at the petiole junction, (Figure 13), were slightly better than the dark vein results. LOD for this trait was around six. Although the phenotype of this trait is similar to the dark vein trait it is slightly easier to correctly identify, which could result in a higher LOD. The leaf drop phenotype was highly associated with linkage group 14 with a LOD of eleven (Figure 8). It is possible that there is a minor QTL for this trait on linkage group 19, which shows an LOD of five to six. The leaf curl phenotype shows association with the front and back of linkage group 14 (Figure 16). The most significant results obtained were from the cell collapse phenotype, which had a LOD around twelve (Figure 11). This phenotype is strongly correlated to the beginning of linkage group 14.

It is important to remember that quantitative trait loci are controlled by more than on gene. The best explanation for each of the phenotypes having different LOD scores is that the minor alleles are segregating independently of the major allele associated with sulfur sensitivity. This was the reasoning behind averaging the LD, CC, DVLJ, and LC phenotypes; a genotype might be sulfur sensitive even if it is missing one minor allele. The large increase in the LOD value of the composite value reinforces the idea that there is one major QTL controlling sulfur, with multiple minor QTLs assorting independently.

Figure 9 shows that QTL analyses are comparative in nature. The trait measured in the other analyses were more or less binomial, with degrees of continuous variation, for the entire population. Figure 9 shows a binomial trait, leaf drop, but the reference population is based on the conditionality of sulfur sensitivity. Structuring a population in this way allows for the identification of minor QTLs.

Limitations

It's possible that leaves, at different stages of maturity, would react differently to sulfur. If this were true, then there is a possibility of misidentifying a QTL responsible for rooting or shoot vigor as a QTL responsible for sulfur sensitivity/tolerance. Any extraneous variables limit your conclusion, as they introduce type 1 & type 2 error. Type one error is rejecting the null hypothesis when it shouldn't be; false positive. Type two error is accepting the null hypothesis when it shouldn't be; false negative.

Population structure is caused by non-random selection on the population; for example: F_1 individuals with poor rooting potential, or susceptibility to root Phylloxera, cold damage, disease complex damage (Eutypa, black rot, downy mildew, etc.). These F_1 individuals have reduced vigor or die, resulting in non-inclusion for sulfur testing, resulting in a non-random distribution of alleles within the testing population, ultimately causing type one or type two error in the QTL analyses.

In the future we should not use the 2005 population, because too many individuals are unusable due to non-random selection. Every precaution should be taken to reduce the loss of true F_1 hybrids (from the germination stage to the testing stage). Individuals should be cloned, and maintained in the greenhouses, prior to being set out in field conditions; the rate of genotype loss can be quite high in the first winter as plants haven't fully established a root system. Simply germinating new plants to replace individuals whom died over the winter doesn't solve the problem, as surviving plants are non-randomly selected to survive cold conditions.

It is highly possible that our population is segregating for Phylloxera resistance, due its pedigree (62.5% to 75%. *V.vinifera*). Norton is resistant to root Phylloxera, so we can hypothesize that the trait is dominant and Norton is heterozygous. Cabernet Sauvignon is highly susceptible to Phylloxera, so we can hypothesize that it is homozygous recessive. Therefore half of the population to be susceptible to Phylloxera; given that only one dominant allele confers resistance.

To reiterate: highly structured populations have very little value ,with regard to QTL mapping; therefore, new populations must be created and sequenced if mapping is to be conducted (very labor intensive and expensive). For the reasons mentioned above, it would be in the best interests of the program to graft all F_1 genotypes to a cold hardy, Phylloxera resistant rootstock. In addition plants should be backed up in the greenhouses.

Norton and some of its progeny are slow to root, and have poor vegetative vigor when grown in pots. This could be attributed the root structure of both parents a bonsai-like effect of having constricted roots. Norton produces only several roots, however these roots are thick, have a deep angle, and grow very long; adaptations lending to drought survival. Cabernet Sauvignon when cloned produces 5-20 roots which are thinner, and each have a high degree of advantageous roots.

Auxin/cytokinin signaling is well documented. Auxins are produced in the shoot apex and translocated to the roots to promote rooting. Cytokinins are produced in the root tip and translocated to the shoots to promote branching and vigor (Su, *et al.* 2011). It is possible that the rooting characteristics are affecting the vegetative uniformity of the clonal population. It is important for the clones to have similar vegetative growth to reduce accumulation of error in sulfur testing; leaf maturity could influence sulfur sensitivity.

Applications

Several paths could be taken, now that punitive markers for sulfur sensitivity have been identified. The first is to identify candidate genes within this region. The 12x *Vitis vinifera* shows many traits at the beginning of linkage group 14 which could possibly cause a sulfur sensitivity phenotype if they happened to be over or under expressed. These genes and promotors include glutathione S-transferase, cupin domains, ester transferases, MYB transcription factors, bHLH transcription factors, aspartyl proteases, cysteine desulfurylase, pyruvate dehydrogenase kinase, ABC transporters, S-adenosylmethionine synthase, lactoperoxidase, metallopeptidases, pyroglutamyl-peptidase, glucose-6-phosphate 1-dehydrogenase, Inositol 3-alpha-galactosyltransferase, membrane proteins, alkaline neutral invertase, TPR transcription factors, bZIP transcription factors, disulfide ozidoreductase, dehydration induced proteins, heat shock proteins, universal stress induced proteins, auxin associated proteins, ethylene signals/pathways, and abscisic acid signals/pathways.

The next path would be to clone the best candidate genes and perform transformation experiments to isolate the causal factor.

The finial path is unrelated from the first two. Now that molecular markers have been identified for sulfur sensitivity they can be incorporated into breeding programs. It appears most likely that sulfur sensitivity is controlled by a gene within the first six million base pairs on linkage group 14. Although this sounds like a large area it is only about one-fifth of the entire length of chromosome 14. Any new progeny produced from a Norton cross could be selected to not be sulfur sensitive by using our markers. This would allow for the production of superior hybrids, which would be more marketable to Midwestern grape growers.

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APPENDIX

Phenotypic values, for each of the 576 F_1 genotypes, are listed in columns under the thirteen categories; Dead, Dark Vein, Dark Leaf at Petiole Junction, Leaf Curl, Leaf Drop, Small Spots, Collapsed Cells, CHlorotic, Salicylic Acid-like (pre-treatment leaf curl), Black Rot, Downy Mildew, Powdery Mildew, and Disease Damage. Each of the 13 catigories could receive a rank of one to four, 1-no indication, 2-possible indication (hard to differentiate), 3-possitive indication, 4-sever indication. GT indicates the F_1 genotype within the population. Reps denotes how many times the genotype was replicated. Score is the average phenotypic value of LD, CC, DLPJ, and LC.

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	54	1	1	1	1	1	1	1	1	1	1	3	1	1
1	212	1	1	1	1	1	2	1	1	3	3	3	1	1
Reps	267	1	1	1	1	1	1	1	3	3	1	3	1	1
4	514	1	1	1	1	1	2	1	1	1	1	1	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	115	1	1	1	1	1	1	1	2	1	1	3	1	1
2	258	1	1	1	1	1	2	1	1	2	1	3	2	1
Reps	283	1	1	1	1	1	1	1	3	3	3	1	1	1
4	402	1	1	1	1	1	1	1	3	1	1	3	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	296	1	1	1	1	1	1	1	1	1	1	3	3	1
3	501	1	1	1	1	2	1	1	1	3	3	3	1	1
Reps	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.125	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	158	1	1	1	1	1	2	1	1	3	3	3	1	1
4	207	1	1	1	1	1	2	1	1	3	3	3	1	1
Reps	326	1	1	1	1	1	1	1	1	1	1	2	1	1
4	332	1	1	1	1	1	1	1	2	1	3	2	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	84	1	1	1	3	1	3	1	2	1	1	2	1	1
5	313	1	1	1	3	1	1	1	1	3	1	2	1	1
Reps	373	1	3	1	1	1	3	1	1	1	3	1	1	1
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.333333	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	124	1	3	1	2	1	1	1	3	3	1	3	1	1
6	168	1	1	1	1	1	3	1	1	1	1	3	1	1
Reps	215	1	3	1	2	1	3	1	1	3	1	3	1	1
5	259	1	3	3	3	1	1	1	1	3	1	3	1	1
Score	502	1	1	1	3	1	3	1	1	1	1	3	1	1
1.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	9	1	1	1	1	1	3	1	1	1	3	3	1	1
9	64	1	1	1	1	1	1	1	1	1	1	3	1	1
Reps	181	1	1	1	3	1	1	1	1	1	1	3	1	1
4	547	1	2	1	1	1	1	1	1	1	1	3	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.125	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	52	1	1	1	1	1	1	1	2	1	1	2	1	1
10	274	1	1	1	1	1	1	1	3	1	3	1	1	1
Reps	372	1	1	1	1	1	1	1	3	1	1	1	1	1
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	27	1	1	1	3	3	3	3	2	3	1	3	1	1
11	425	1	3	1	3	1	3	2	2	3	1	2	1	1
Reps	469	1	1	1	3	3	3	3	2	1	1	3	1	1
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	87	1	1	1	2	1	1	1	2	3	1	2	1	1
12	231	1	1	1	1	2	1	1	2	1	1	1	1	1
Reps	448	1	1	1	1	3	1	1	2	1	1	1	1	1
4	515	1	1	1	2	1	1	1	1	1	1	2	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.3125	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	253	1	1	1	1	1	3	1	1	1	1	2	1	1
13	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reps	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	119	1	1	1	3	4	1	2	1	1	1	3	2	1
14	312	1	1	1	3	3	3	4	1	1	1	2	1	1
Reps	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.625	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	93	1	1	2	3	3	3	1	3	1	1	1	1	1
15	176	1	1	1	3	3	3	1	4	1	1	2	1	1
Reps	255	1	3	3	3	1	3	2	4	1	1	1	1	1
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.166667	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	306	1	1	1	2	1	3	1	1	1	1	1	1	1
16	508	1	1	1	2	1	3	1	1	1	1	1	1	1
Reps	513	1	1	1	3	2	3	1	1	1	1	1	1	1
4	545	1	1	1	1	1	1	1	1	1	1	1	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.3125	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	42	1	1	1	2	1	1	1	1	3	1	3	1	1
17	90	1	1	1	1	1	1	1	1	1	1	1	1	1
Reps	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.125	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	15	1	3	1	2	2	3	3	2	1	1	3	3	1
18	106	1	3	1	2	1	3	1	2	3	1	1	3	1
Reps	211	1	1	1	1	1	1	1	2	3	1	3	3	1
5	361	1	3	3	1	3	3	1	2	1	1	1	1	1
Score	440	1	1	1	1	3	3	3	2	1	1	1	1	1
1.65	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	67	1	3	3	3	1	3	2	1	3	3	1	1	1
19	157	1	1	3	3	1	3	3	1	1	1	1	1	1
Reps	239	1	1	3	3	1	3	2	1	2	3	1	1	1
5	536	1	3	1	3	2	3	1	1	1	1	1	1	1
Score	575	1	3	3	1	1	3	1	1	3	3	2	1	1
2.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	152	1	1	1	3	1	3	3	1	1	1	2	1	1
23	192	1	1	1	3	1	3	3	1	3	1	3	1	1
Reps	359	1	1	1	3	1	3	3	1	3	1	3	1	1
5	415	1	1	3	3	1	3	3	1	1	1	1	1	1
Score	551	1	1	1	3	3	3	1	1	1	1	1	1	1
2.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	108	1	1	1	1	1	3	1	2	3	1	2	1	1
25	271	1	1	1	1	1	3	1	2	1	1	2	1	1
Reps	340	1	1	1	3	1	3	1	2	1	1	1	1	1
5	346	1	1	1	1	1	3	1	2	1	1	1	1	1
Score	380	1	3	1	1	1	3	1	3	1	1	1	1	1
1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	155	1	1	1	1	1	1	1	1	2	3	1	3	1
26	441	1	3	1	1	1	3	1	1	2	3	2	1	1
Reps	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	73	1	1	1	1	1	1	1	1	1	1	1	1	1
28	107	1	1	1	1	1	1	1	1	1	3	1	3	1
Reps	109	1	1	1	1	1	1	1	1	1	1	1	1	1
4	523	1	2	1	1	1	1	1	1	1	1	1	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	89	1	1	1	1	1	3	1	1	3	1	3	1	1
30	145	1	3	1	1	1	3	1	1	1	3	3	1	1
Reps	500	1	1	1	1	1	1	2	1	3	3	1	1	1
4	538	1	1	1	1	1	3	1	1	1	1	1	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.0625	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	384	1	1	1	2	1	3	1	1	2	1	2	1	1
31	464	1	1	1	1	1	3	1	3	3	3	2	1	1
Reps	571	1	2	2	1	1	3	1	1	3	3	1	1	1
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.166667	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	357	1	1	1	1	1	3	3	1	1	3	3	3	1
32	405	1	1	1	1	3	3	3	4	1	3	1	3	1
Reps	449	1	3	1	1	1	3	1	1	1	3	3	3	1
4	564	1	1	1	1	1	3	1	1	1	1	3	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.375	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	71	1	1	2	1	1	3	1	1	1	3	2	1	3
33	110	1	1	1	1	1	1	1	3	3	3	2	1	3
Reps	172	1	1	1	1	1	3	1	4	1	3	3	1	3
4	180	1	1	1	1	1	3	1	1	1	1	1	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.0625	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	17	1	1	1	1	1	1	1	1	1	3	2	1	3
35	282	1	1	1	1	1	1	1	1	1	3	2	1	3
Reps	351	1	1	1	1	1	1	1	1	1	3	2	1	3
5	487	1	1	1	1	1	1	1	1	1	3	2	1	3
Score	568	1	1	1	1	1	1	1	1	3	1	1	1	1
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	70	1	1	1	1	3	1	3	3	1	3	2	1	1
36	142	1	3	3	2	1	3	1	1	2	3	3	1	1
Reps	336	1	3	3	1	1	3	1	1	1	3	3	1	1
4	497	1	1	1	1	1	3	1	1	1	3	3	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.5625	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	151	1	1	1	3	1	1	3	1	1	1	1	1	1
37	257	1	3	3	1	1	1	2	1	1	1	1	1	1
Reps	339	1	3	3	1	1	1	3	1	1	1	2	1	1
4	391	1	1	1	1	1	3	3	1	1	1	1	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.8125	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	121	1	1	1	1	3	1	1	1	1	3	3	1	1
38	166	1	1	2	1	3	3	3	1	1	3	3	2	1
Reps	242	1	1	3	1	2	3	3	1	1	1	3	1	1
5	250	1	1	2	1	3	3	3	1	1	3	3	2	1
Score	330	1	1	3	1	2	3	3	1	1	1	3	1	1
2.116667	-	-	-	-	-	-	-	3	-	-	-	-	-	-
GT	263	1	1	1	1	1	1	3	1	1	3	3	1	1
39	356	1	1	1	1	1	3	1	1	1	3	3	1	1
Reps	432	1	1	1	1	1	3	1	1	1	3	3	1	1
5	510	1	1	1	1	1	3	1	1	1	1	3	1	1
Score	560	1	1	1	1	1	1	1	1	1	1	2	1	1
1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	179	1	1	1	1	1	3	1	1	1	1	2	1	1
40	553	1	1	1	1	1	1	1	1	1	1	2	1	1
Reps	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	80	1	1	1	3	1	3	1	1	1	1	3	3	1
41	222	1	1	1	2	2	2	1	1	1	1	3	3	3
Reps	379	1	1	1	1	3	2	1	1	1	1	3	3	3
4	512	1	1	1	1	3	2	1	1	1	1	3	3	3
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	41	1	2	1	1	1	3	1	1	1	1	1	3	1
43	419	1	2	2	1	1	3	1	1	1	1	1	3	1
Reps	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.125	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	86	4	1	1	1	1	1	1	1	1	1	1	1	1
47	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reps	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	4	1	3	3	1	3	3	1	1	1	1	2	1	1
48	299	1	3	3	3	2	3	1	1	1	1	3	1	1
Reps	503	1	3	3	3	2	3	1	1	1	1	1	1	1
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.166667	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	329	1	3	2	1	3	1	1	1	1	3	3	3	1
50	450	1	1	2	1	1	1	1	1	1	2	3	3	1
Reps	509	1	1	3	1	1	1	1	1	3	2	3	1	1
4	554	1	1	1	3	1	1	1	1	3	1	3	2	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	131	1	1	1	1	1	3	1	1	1	2	3	1	1
52	174	1	1	1	1	1	3	1	1	1	1	3	1	1
Reps	374	1	1	2	1	1	3	1	1	1	1	3	1	1
4	495	1	1	1	1	1	3	1	1	1	1	3	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.0625	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	49	1	3	3	1	3	1	1	1	1	3	2	3	3
53	261	1	3	3	1	3	3	1	1	1	3	2	3	3
Reps	576	1	3	1	1	3	3	1	1	1	3	2	3	3
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.833333	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	30	1	1	1	1	2	1	1	1	1	1	3	1	1
54	101	1	2	1	1	3	3	1	1	1	1	3	1	3
Reps	127	1	1	1	1	1	3	1	1	1	2	3	1	1
5	193	1	1	1	1	1	1	1	1	1	1	3	1	1
Score	416	1	3	3	3	3	3	1	1	1	1	3	1	1
1.45	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	350	1	1	1	2	3	3	1	1	1	1	2	1	1
55	438	1	1	1	1	1	3	1	1	1	1	1	1	1
Reps	465	1	1	1	1	1	2	2	1	1	1	3	1	2
4	522	1	1	1	1	1	3	1	1	1	1	1	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	51	1	2	1	3	1	3	1	3	3	1	1	1	1
56	383	1	1	1	3	1	3	1	3	3	1	1	1	1
Reps	401	1	1	1	2	1	3	1	3	3	1	1	1	1
4	486	1	1	1	2	1	3	1	2	3	1	1	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.375	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	199	1	1	1	3	1	3	3	1	1	3	3	1	3
57	200	1	3	3	3	3	3	2	1	1	3	3	1	3
Reps	322	1	3	1	1	3	3	1	1	1	3	3	1	3
6	390	1	3	3	1	3	3	3	1	1	1	2	1	3
Score	396	1	3	3	3	3	3	1	1	1	1	3	3	3
2.375	567	1	3	3	3	3	3	3	1	1	1	2	1	3
GT	268	1	2	1	1	2	3	1	1	1	3	1	1	1
58	444	1	3	1	2	1	3	1	1	1	2	1	1	1
Reps	511	1	2	1	1	1	3	1	1	1	1	1	1	1
4	556	1	1	1	1	1	1	1	1	1	1	1	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.125	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	33	1	1	1	1	1	3		1	1	2	3	1	3
59	249	1	3	3	1	1	3		1	1	3	3	1	1
Reps	301	1	1	3	1	1	3	1	1	1	3	3	1	1
4	309	1	3	3	1	3	3	1	1	1	2	1	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	26	1	1	1	3	3	1	3	1	1	1	3	1	1
60	447	4	1	1	1	1	1	1	1	1	1	1	1	1
Reps	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	126	1	1	2	3	1	1	2	1	1	1	2	1	2
63	139	1	1	2	3	1	1	2	1	1	3	3	1	2
Reps	557	1	2	2	1	1	1	1	1	1	3	2	1	3
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	59	1	3	3	3	3	3	1	1	1	3	3	1	1
64	134	1	3	3	3	3	3	2	1	1	1	2	1	2
Reps	167	1	1	1	1	1	1	1	1	1	1	1	1	1
4	470	1	3	3	3	3	3	3	1	1	1	3	1	3
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.3125	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	7	1	1	1	1	1	3	1	1	1	1	3	3	3
65	69	1	1	1	1	1	2	1	1	1	3	2	3	2
Reps	360	1	1	1	1	1	3	1	1	1	3	3	1	1
5	456	1	1	1	1	3	2	1	1	1	3	3	1	2
Score	546	1	1	1	1	1	3	1	1	1	1	1	1	2
1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	243	1	1	1	3	3	3	2	1	1	2	3	1	3
66	355	1	1	1	3	1	3	3	1	1	2	2	1	2
Reps	399	1	1	1	1	1	3	3	1	1	1	1	1	2
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.916667	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	20	1	1	1	3	1	3	3	1	1	1	2	1	1
67	35	1	3	1	3	1	3	1	1	1	3	3	1	1
Reps	218	1	3	3	3	2	3	2	1	1	2	2	1	1
5	252	1	3	3	1	3	3	1	1	1	1	1	1	1
Score	518	1	3	3	1	3	3	1	1	1	1	1	1	1
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	196	1	1	1	1	1	1	2	4	1	4	2	3	4
68	246	1	1	1	1	1	3	2	4	1	3	3	3	4
Reps	324	1	3	3	1	1	3	3	1	1	3	3	1	3
6	404	1	3	3	2	3	3	2	1	1	3	3	3	3
Score	433	1	3	1	3	1	3	3	3	1	1	2	1	1
1.833333	485	1	3	3	3	1	3	1	1	1	3	1	1	3
GT	77	1	1	1	3	2	1	3	1	1	3	3	1	3
69	141	1	1	1	2	1	1	1	3	1	3	1	1	3
Reps	254	1	2	2	3	2	1	3	1	1	3	3	1	3
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	173	1	1	1	1	1	1	2	1	1	2	2	1	1
70	323	1	3	3	1	3	1	1	3	1	2	2	3	3
Reps	387	1	3	3	3	3	3	1	1	1	1	1	1	1
5	431	1	1	1	1	1	1	2	1	1	1	1	1	1
Score	439	1	1	1	1	3	1	1	3	1	3	3	1	1
1.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	3	1	1	1	1	1	3	2	4	1	3	3	1	3
73	16	1	1	1	1	1	3	3	1	1	3	3	1	3
Reps	28	1	1	1	3	3	3	3	1	1	3	3	1	3
5	367	1	1	1	3	3	3	1	1	1	2	2	1	2
Score	499	1	1	1	3	3	3	3	1	1	3	3	1	3
1.95	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	47	1	1	1	2	1	2	1	1	3	1	1	1	1
74	103	1	1	1	2	1	1	2	1	3	1	1	1	1
Reps	273	1	1	1	1	1	1	1	1	3	3	3	1	3
4	517	1	1	1	1	1	1	1	1	1	1	1	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.1875	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	37	1	1	1	1	1	3	1	1	1	1	3	1	1
76	143	1	1	1	1	1	1	1	2	1	1	1	1	1
Reps	443	1	1	1	1	2	3	1	1	1	1	1	1	1
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.083333	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	105	1	1	3	3	1	3	3	1	2	1	3	1	3
77	185	1	1	3	3	1	1	3	1	1	3	3	1	3
Reps	362	1	3	3	3	1	3	3	1	2	3	3	1	3
5	481	1	1	1	1	1	1	3	1	1	3	3	1	3
Score	521	1	3	3	3	3	3	3	1	1	3	3	1	3
2.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	56	1	3	1	3	1	1	2	1	1	1	3	1	3
78	83	1	3	3	1	3	3	2	1	1	1	3	1	3
Reps	457	1	3	3	3	3	3	3	1	1	1	3	1	3
5	462	1	3	3	3	3	3	3	1	1	1	2	1	3
Score	489	1	3	3	3	3	3	3	1	1	3	3	1	3
2.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	349	1	1	3	1	3	3	1	1	3	1	2	1	1
79	364	1	1	1	1	1	1	1	1	1	1	1	1	1
Reps	540	1	1	1	1	1	3	1	1	3	3	3	1	3
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.333333	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	118	1	1	1	1	2	1	1	2	1	1	3	2	1
101	228	1	1	1	1	2	1	1	2	1	1	3	2	1
Reps	285	1	1	1	2	1	1	1	1	1	1	3	1	1
4	562	1	1	1	1	3	1	1	1	1	1	3	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.3125	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	150	1	1	1	1	1	3	1	2	2	1	3	1	1
102	292	1	1	1	1	1	3	1	1	1	1	3	1	1
Reps	297	1	1	1	1	1	1	1	1	1	1	1	1	1
5	314	1	1	1	1	1	3	1	2	1	1	3	1	1
Score	466	1	1	1	1	1	1	1	1	1	1	1	1	1
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	190	1	1	2	1	1	3	2	3	1	2	2	2	1
103	213	1	1	1	1	1	3	3	2	1	3	2	3	1
Reps	288	1	3	1	1	1	3	1	1	1	1	1	1	1
5	422	1	3	3	1	2	3	2	1	1	3	1	2	1
Score	526	1	1	1	1	1	3	1	1	1	3	1	1	1
1.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	97	1	2	1	1	1	1	1	1	1	1	1	1	1
104	184	1	1	1	1	1	1	1	1	3	3	2	1	1
Reps	275	1	1	1	1	1	1	1	1	3	3	2	1	1
4	417	1	1	1	1	1	1	1	1	1	3	1	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	182	1	1	1	1	1	3	1	3	1	3	2	1	1
105	411	1	3	1	1	1	3	1	2	1	3	3	1	1
Reps	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	61	1	1	1	2	2	3	3	1	1	3	3	1	1
106	216	1	1	1	1	1	3	1	1	1	3	1	1	1
Reps	437	1	1	3	1	3	3	3	1	1	3	3	1	1
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.833333	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	81	1	3	1	1	2	3	1	1	3	3	3	1	1
108	175	1	1	1	1	1	3	1	1	3	3	3	1	1
Reps	203	1	1	1	1	1	3	1	1	3	3	3	1	1
4	221	1	1	1	1	1	3	1	1	1	1	1	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.0625	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	403	1	3	3	2	2	3	1	1	1	3	1	1	1
109	570	1	3	3	2	2	3	1	1	1	3	1	1	1
Reps	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	50	1	1	1	2	1	1	1	1	1	2	3	1	1
110	91	1	1	1	2	1	1	1	1	1	1	3	1	1
Reps	388	1	1	1	2	1	1	1	1	1	1	3	1	1
5	504	1	1	1	2	1	1	1	1	3	1	3	1	1
Score	539	1	1	1	2	1	1	1	1	1	1	3	1	1
1.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	201	1	1	1	2	1	3	1	1	2	3	3	1	1
111	234	1	1	1	2	1	3	1	1	2	3	3	1	1
Reps	328	1	1	1	1	1	1	1	1	1	3	1	1	1
5	338	1	1	1	2	1	3	1	1	1	3	1	1	1
Score	531	1	1	1	1	1	1	1	3	1	3	1	1	1
1.15	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	75	1	1	1	3	1	3	1	1	1	1	3	1	3
112	237	1	3	3	1	2	3	2	1	1	1	3	1	3
Reps	475	1	3	3	2	3	3	1	2	1	1	2	1	2
4	477	1	3	3	1	3	3	1	2	1	1	1	1	3
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.9375	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	29	1	1	1	1	3	2	3	1	1	1	2	1	2
113	186	1	3	3	3	3	3	3	1	3	1	2	1	3
Reps	303	1	3	3	3	3	2	3	1	1	1	2	1	3
4	409	1	3	3	3	3	3	3	1	1	1	1	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	276	1	2	1	1	1	3	1	1	1	1	1	1	1
114	393	1	1	1	1	1	1	2	2	1	1	2	1	1
Reps	413	1	3	3	3	3	3	1	1	1	1	1	1	1
4	476	1	2	1	1	2	3	1	1	1	1	3	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	78	1	3	3	3	3	3	2	1	1	1	2	1	2
115	435	1	3	3	3	3	3	3	1	1	1	2	1	2
Reps	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.875	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	289	1	1	2	1	1	2	1	1	3	1	2	1	1
116	394	1	3	3	1	3	3	1	1	3	1	3	1	1
Reps	488	1	1	2	1	3	3	1	1	3	1	2	1	1
4	532	1	2	2	1	1	3	1	1	1	1	2	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.5625	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	369	1	3	3	3	3	2	2	1	1	3	2	1	2
117	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reps	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	114	1	3	2	1	2	1	2	1	1	1	3	1	2
118	286	1	3	3	2	3	3	3	1	1	1	3	1	2
Reps	335	1	3	3	2	3	3	3	3	1	1	3	1	2
5	382	1	3	3	2	3	1	1	1	1	1	2	1	1
Score	458	1	3	3	3	3	1	3	1	1	1	3	1	2
2.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	44	1	2	2	2	3	3	1	1	1	1	1	1	1
119	125	1	2	2	2	3	3	3	1	1	1	1	1	1
Reps	194	1	3	3	3	3	3	3	1	1	1	2	1	1
5	293	4	1	1	1	1	1	1	1	1	1	3	1	1
Score	541	1	3	3	2	3	3	1	1	1	1	2	1	1
2.15	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	62	1	1	1	1	1	1	1	1	1	2	2	1	1
120	452	1	1	1	1	3	1	1	1	1	1	3	1	3
Reps	519	1	2	1	1	1	1	1	1	1	1	2	1	1
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.166667	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	120	1	2	1	2	2	3	1	1	3	3	2	1	1
122	272	1	2	1	1	1	3	2	2	3	3	2	1	2
Reps	498	1	2	1	1	2	3	1	2	1	2	2	1	1
4	558	1	1	1	1	1	2	2	1	1	1	2	1	2
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.3125	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	2	1	1	1	1	2	3	3	1	1	1	2	1	2
123	165	1	1	1	2	3	1	3	1	1	1	2	1	2
Reps	376	1	1	1	2	2	1	3	1	1	1	1	1	1
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	161	1	1	2	1	1	1	1	1	1	2	3	1	2
124	229	1	1	3	1	2	3	1	1	1	2	2	1	1
Reps	378	1	1	3	1	2	3	1	1	1	1	2	1	1
5	484	1	3	3	1	2	3	1	1	1	1	2	1	1
Score	572	1	3	3	1	2	3	1	1	1	1	2	1	2
1.65	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	284	1	3	3	1	3	3	2	1	1	2	3	1	3
125	310	1	3	3	1	3	3	3	1	1	2	3	1	2
Reps	544	1	3	3	1	3	3	3	1	1	2	2	1	1
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.416667	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	102	1	1	1	2	1	3	1	1	3	2	3	1	1
126	344	1	3	1	2	1	1	1	1	3	3	1	1	1
Reps	543	1	3	1	2	1	3	1	1	3	3	3	1	1
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	58	1	1	2	1	3	3	1	1	1	2	2	1	2
127	183	1	1	2	2	3	3	1	1	1	1	3	1	3
Reps	461	1	1	1	1	2	3	1	1	1	1	2	1	3
5	506	1	1	2	2	3	3	1	1	1	1	1	1	1
Score	565	1	3	3	3	2	3	1	1	1	1	1	1	1
1.85	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	163	1	3	3	3	3	3	3	1	1	3	3	1	3
128	331	1	3	3	3	3	3	3	1	1	1	3	1	2
Reps	479	1	3	3	3	3	3	3	1	1	1	2	1	1
5	492	1	3	3	3	3	3	3	1	1	1	2	1	2
Score	507	1	3	3	3	3	3	3	1	1	1	2	1	1
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	34	1	1	3	2	2	3	1	1	1	1	1	3	1
129	342	1	3	3	3	1	3	1	1	1	1	1	3	1
Reps	352	1	1	1	1	1	1	1	1	1	1	3	2	1
4	446	4	1	1	1	1	1	1	1	1	1	1	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	63	1	1	2	1	1	2	2	1	1	1	3	1	2
130	79	1	1	2	1	1	2	1	1	1	1	3	1	1
Reps	280	1	1	2	2	1	3	2	1	1	1	3	1	2
5	400	1	1	3	2	1	3	3	1	1	1	2	1	2
Score	548	1	1	3	2	1	3	3	1	1	1	2	1	2
1.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	195	1	3	3	2	2	3	1	1	1	1	2	3	1
131	319	1	3	3	2	2	3	1	1	1	1	1	2	1
Reps	385	1	3	3	2	3	3	1	1	1	1	1	3	1
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.083333	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	23	1	1	1	2	1	3	2	1	1	1	3	1	2
132	76	1	1	1	2	1	3	1	1	1	1	3	1	1
Reps	210	1	1	1	2	1	3	3	1	1	3	3	1	3
5	308	1	1	1	2	1	3	1	1	1	1	2	1	2
Score	467	1	1	1	2	1	3	2	1	1	1	3	1	3
1.45	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	43	1	1	1	1	2	3	1	1	1	1	1	1	1
133	189	1	1	1	2	2	3	1	1	1	1	1	1	1
Reps	236	4	1	1	1	1	1	1	1	1	1	1	1	1
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	315	1	1	1	1	1	1	1	1	1	1	1	1	1
134	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reps	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	36	1	1	1	3	1	1	1	1	1	2	1	1	1
135	94	1	1	1	3	1	2	1	1	1	1	3	1	3
Reps	214	1	1	1	3	1	1	1	1	1	1	3	1	1
4	318	1	1	1	3	1	1	1	1	1	1	1	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	202	1	1	1	1	1	1	1	3	1	1	1	1	1
136	294	1	1	1	1	1	2	1	2	1	1	1	1	1
Reps	325	1	1	1	1	1	1	1	2	1	3	1	1	1
5	563	1	1	1	2	1	1	1	1	1	1	2	1	1
Score	566	1	1	1	1	1	3	1	1	1	1	3	1	1
1.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	1	1	1	1	1	1	3	1	1	1	1	1	1	1
137	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reps	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	412	1	3	1	3	2	3	1	1	1	1	3	1	1
138	429	1	3	1	3	2	3	1	1	1	1	2	1	1
Reps	493	1	3	2	3	2	3	1	1	1	1	3	1	1
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.833333	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	88	1	1	1	1	1	3	1	1	1	1	3	1	3
139	241	1	1	1	1	1	3	1	1	1	1	3	1	1
Reps	251	1	1	1	1	1	3	1	1	1	3	3	1	3
5	410	1	1	1	1	1	1	1	1	1	1	3	1	1
Score	574	1	1	1	1	1	1	1	1	1	2	3	1	1
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	170	1	3	3	3	3	3	3	1	1	1	2	1	1
140	205	1	3	3	2	2	3	1	1	1	1	3	1	1
Reps	270	1	3	3	2	2	3	3	1	1	1	2	1	1
4	305	1	1	3	2	2	3	1	1	1	1	3	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.375	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	92	1	2	1	3	3	3	2	1	1	1	3	1	2
141	279	1	3	1	3	2	3	2	1	1	1	3	1	2
Reps	316	1	2	1	3	2	3	2	1	1	1	3	1	2
5	406	1	3	1	3	3	3	2	1	1	1	3	1	2
Score	453	1	3	1	3	3	3	2	1	1	1	3	1	2
2.15	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	38	1	1	1	1	1	1	1	1	1	1	1	1	1
142	290	1	1	1	1	1	1	1	1	1	1	1	1	1
Reps	426	1	1	1	1	1	1	1	1	1	1	1	1	1
5	483	1	1	1	2	1	1	1	1	1	1	1	1	1
Score	533	1	1	1	1	1	1	1	1	1	1	1	1	1
1.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	104	1	1	1	3	1	3	1	1	1	2	3	1	1
143	311	1	1	3	1	1	1	1	1	1	1	3	1	1
Reps	455	1	1	1	3	1	3	1	1	1	1	3	1	1
4	534	1	1	1	3	1	3	1	1	1	1	3	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	31	1	1	1	1	1	1	1	1	1	1	1	1	1
144	98	1	1	1	1	1	1	1	1	1	1	3	1	1
Reps	138	1	1	1	1	3	1	3	1	1	1	3	1	2
5	197	1	1	1	1	1	1	1	1	1	1	3	1	1
Score	528	1	1	1	1	1	1	1	1	1	1	3	1	1
1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	191	1	2	2	3	1	2	3	1	1	1	4	1	2
145	424	1	3	3	3	1	3	3	3	1	3	3	1	2
Reps	569	1	1	1	2	1	1	2	1	1	1	2	1	2
4	573	1	3	3	3	1	3	3	1	1	3	3	1	2
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.1875	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	85	1	1	1	1	1	3	2	1	1	1	3	1	3
146	95	1	1	1	1	3	3	1	1	1	3	1	1	1
Reps	129	1	1	1	1	1	1	1	3	1	3	1	1	1
6	381	1	1	3	1	1	3	1	1	1	3	1	1	1
Score	389	1	1	1	1	3	3	1	1	1	1	1	1	1
1.333333	395	1	1	2	1	1	3	1	1	1	3	1	1	1
GT	354	1	3	3	1	3	3	1	1	1	3	1	1	1
147	407	1	3	3	3	3	3	1	1	1	1	1	1	1
Reps	490	1	3	3	1	3	3	1	1	1	1	1	1	1
4	537	1	3	3	1	3	3	1	1	1	1	1	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.125	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	32	1	1	1	1	1	3	1	1	1	3	1	1	1
148	123	1	1	1	1	1	1	2	1	1	3	3	1	2
Reps	358	1	1	1	1	1	1	1	1	1	1	1	1	1
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.083333	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	240	1	1	1	1	1	2	2	1	1	3	3	1	2
149	277	1	1	1	2	1	1	1	3	1	3	3	1	1
Reps	287	1	1	1	1	1	1	1	1	1	1	3	1	1
5	430	1	1	1	1	1	1	1	1	1	1	3	1	1
Score	516	1	1	1	1	1	3	1	1	1	1	1	1	1
1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	6	1	1	1	1	1	1	1	1	1	3	3	1	3
150	10	1	1	1	1	1	2	1	1	1	3	3	1	3
Reps	72	1	1	1	2	1	1	1	1	1	3	3	1	1
5	204	1	1	1	1	1	1	1	1	1	1	1	1	1
Score	223	1	1	1	1	1	1	1	1	1	1	1	1	1
1.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	133	4	1	1	1	1	1	1	1	1	1	1	1	1
151	209	1	2	2	3	4	1	1	1	1	2	2	1	1
Reps	368	1	2	2	3	4	3	3	1	1	2	2	1	1
5	549	1	2	2	3	4	3	3	1	1	2	2	1	1
Score	552	1	3	3	3	3	3	3	1	1	2	2	1	1
2.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	19	1	1	1	1	1	3	1	1	1	1	3	1	1
152	365	1	1	1	1	1	2	1	1	1	1	3	1	1
Reps	414	1	1	1	1	1	1	1	1	1	3	3	1	1
5	542	1	1	1	1	1	1	1	1	1	1	1	1	1
Score	550	1	1	1	1	1	1	1	1	1	1	1	1	1
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	244	1	1	1	3	1	3	3	1	1	3	2	1	2
153	266	1	1	1	3	1	3	3	1	1	2	2	1	2
Reps	317	1	1	1	3	1	3	3	1	1	2	2	1	2
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	39	1	1	1	1	1	1	1	1	1	2	2	1	2
154	154	1	1	1	3	1	2	2	1	1	2	2	2	2
Reps	217	1	1	1	3	1	3	2	3	1	3	1	1	2
5	468	1	2	2	1	2	3	2	1	1	1	1	1	1
Score	559	1	3	3	3	2	3	3	1	1	3	1	1	2
1.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	8	1	1	1	1	1	3	1	1	1	1	4	1	1
155	434	1	1	1	1	1	1	1	1	1	1	1	1	1
Reps	442	1	1	2	1	1	2	1	1	1	3	3	1	1
4	463	1	1	1	1	1	3	1	1	1	1	4	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.0625	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	82	1	1	1	1	1	1	1	2	1	2	3	1	3
156	162	1	2	2	1	2	3	1	1	1	3	4	1	3
Reps	220	1	1	1	1	1	1	1	1	1	1	3	1	1
4	474	1	3	3	1	1	1	1	1	1	1	1	1	3
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	25	1	1	1	1	1	1	1	1	1	1	3	1	3
157	99	1	1	1	3	1	3	1	1	1	1	3	1	3
Reps	363	1	1	1	1	1	3	2	1	1	1	3	1	3
5	524	1	1	1	1	1	1	3	1	1	1	2	1	3
Score	535	1	1	1	1	1	1	1	1	1	1	1	1	1
1.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	149	1	1	1	2	1	3	1	1	1	1	2	1	1
158	164	1	2	2	2	1	3	1	1	1	1	3	1	1
Reps	337	1	1	1	1	1	2	1	1	1	3	3	1	1
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.25	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	48	1	1	1	1	1	1	1	1	1	1	3	1	3
159	136	1	1	1	1	1	1	1	1	1	4	1	1	1
Reps	264	1	1	1	1	1	1	1	1	1	3	2	1	3
5	377	1	1	2	1	1	1	2	1	1	1	2	1	3
Score	436	1	1	1	1	1	3	1	1	1	1	1	1	1
1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	128	1	3	3	3	3	1	3	1	1	1	2	1	1
160	187	1	3	3	3	3	1	3	1	1	2	2	1	1
Reps	408	1	3	3	3	3	1	3	1	1	1	2	1	1
4	561	1	3	3	3	3	1	2	1	1	1	1	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.9375	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	60	1	1	1	1	2	1	1	1	1	1	2	1	3
161	116	1	1	1	3	3	3	1	1	1	1	3	1	1
Reps	298	1	1	1	3	2	1	1	1	1	3	3	1	3
5	327	1	1	1	3	3	2	1	1	1	3	2	1	1
Score	428	1	1	1	2	3	3	1	1	1	1	3	1	3
1.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	96	1	1	2	1	1	3	2	1	1	1	3	1	1
162	281	1	2	3	1	1	1	3	1	1	1	3	1	1
Reps	471	1	3	3	1	3	3	1	1	1	1	2	1	1
4	520	1	1	1	1	3	1	1	1	1	1	3	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	5	1	1	1	1	1	3	1	1	1	1	1	1	1
163	40	1	1	1	1	1	3	1	1	1	2	1	1	1
Reps	137	1	1	3	2	1	3	1	1	1	3	2	1	1
5	370	1	1	3	1	1	3	1	1	1	2	1	1	1
Score	478	1	1	3	1	1	2	1	1	1	1	1	1	1
1.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	53	1	1	1	2	1	1	1	1	1	1	2	1	1
164	112	1	1	1	1	1	1	1	1	1	3	2	1	1
Reps	226	1	1	1	1	1	1	1	1	1	1	1	1	1
5	345	1	1	1	1	1	1	1	1	1	1	1	1	1
Score	397	1	2	1	1	1	1	1	1	1	1	1	1	1
1.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	74	1	1	1	3	1	3	3	1	1	1	2	1	1
165	156	1	1	1	3	3	3	2	1	1	1	1	1	1
Reps	420	1	3	3	3	1	3	3	1	1	3	2	1	1
4	496	1	3	3	3	3	3	2	1	1	1	1	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.375	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	24	1	1	3	2	1	2	2	1	2	1	3	1	3
166	140	1	2	1	2	1	2	2	1	2	2	3	1	2
Reps	148	1	1	1	3	1	2	1	1	2	1	2	1	1
5	278	1	1	1	3	3	3	3	1	1	1	2	1	2
Score	366	1	1	1	2	1	3	3	1	1	1	3	1	3
1.85	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	12	1	1	1	2	2	3	2	1	1	1	2	1	1
167	18	1	1	1	3	3	1	3	1	1	1	2	1	1
Reps	21	1	1	1	3	2	1	3	1	1	1	2	1	1
5	247	1	1	1	3	1	1	3	1	1	1	2	1	1
Score	459	1	1	1	2	1	3	2	1	1	1	2	1	1
2	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	130	1	1	1	3	3	3	1	1	1	2	2	1	1
168	245	1	1	1	1	3	3	2	1	1	3	2	1	1
Reps	454	1	1	1	3	4	3	2	1	1	1	1	1	1
5	472	1	1	1	3	3	3	2	1	1	2	2	1	1
Score	491	1	1	1	3	3	3	3	1	1	1	2	1	1
2.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	144	1	1	1	1	1	1	1	1	3	1	1	1	1
169	178	1	1	1	2	1	1	1	1	2	1	2	1	1
Reps	232	1	1	1	1	1	1	1	1	1	1	2	1	1
5	269	1	1	1	1	1	1	1	1	3	1	1	1	1
Score	480	1	1	1	3	1	3	1	1	2	1	1	1	1
1.15	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	46	1	2	1	2	3	3	3	1	1	1	2	1	1
170	147	1	3	2	3	3	3	3	1	1	2	2	1	1
Reps	482	1	2	1	3	3	3	3	1	1	1	2	1	1
4	555	1	3	3	3	3	3	2	1	1	1	2	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.5625	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	22	1	1	1	3	1	1	3	1	1	1	2	1	1
171	386	1	1	3	3	3	2	3	1	1	1	2	1	1
Reps	505	1	1	1	3	4	1	1	1	1	1	1	1	1
4	525	1	1	3	3	3	3	3	1	1	2	2	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.5625	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	153	1	1	1	3	3	1	3	1	1	1	2	1	1
172	256	1	1	1	3	3	1	3	3	1	1	1	1	1
Reps	260	1	1	1	3	3	1	3	1	1	1	1	1	1
4	353	1	1	1	3	3	1	2	1	1	2	2	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.4375	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	13	1	1	1	1	1	1	1	1	1	1	1	1	1
173	235	1	1	1	1	1	1	1	1	1	1	1	1	1
Reps	398	1	1	1	1	1	1	1	1	1	1	1	1	1
4	527	1	1	1	1	1	1	1	1	1	1	1	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	57	1	2	1	1	1	1	1	1	1	3	3	1	1
174	66	1	3	1	1	1	1	1	1	1	2	2	1	1
Reps	224	1	1	1	1	1	1	1	1	1	2	2	1	1
4	445	1	1	1	2	1	1	1	1	1	2	2	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.0625	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	55	1	2	1	2	1	2	1	1	3	2	1	1	1
175	117	1	1	3	3	1	3	1	1	2	2	1	1	1
Reps	135	1	1	1	2	1	3	1	1	3	2	1	1	1
4	341	1	3	3	2	1	3	1	1	2	1	2	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.5625	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	100	1	1	1	1	1	1	1	1	1	1	1	1	1
176	132	1	1	1	1	1	1	1	1	1	1	2	1	1
Reps	227	1	1	1	1	1	1	1	1	1	2	3	1	1
5	265	1	1	1	1	1	1	1	1	1	1	1	1	1
Score	427	1	1	1	1	1	1	1	1	1	1	1	1	1
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	230	1	1	3	1	3	3	1	1	1	3	1	1	1
177	302	1	2	1	1	1	3	2	1	1	3	3	1	3
Reps	320	1	1	3	1	1	3	1	1	1	1	2	1	2
5	333	1	1	3	2	1	3	1	1	1	1	1	1	1
Score	473	1	1	3	1	3	3	1	1	1	1	3	1	1
1.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	45	1	1	1	1	1	3	1	1	1	1	1	1	1
178	171	1	1	1	2	1	3	2	1	1	1	2	1	2
Reps	177	1	1	2	2	2	1	1	1	1	1	2	1	1
4	248	1	1	1	2	1	1	1	1	1	1	1	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.375	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	113	1	1	1	1	1	1	1	1	1	1	1	1	1
179	225	1	1	1	1	1	1	1	1	1	1	1	1	1
Reps	460	1	1	1	1	1	1	1	1	1	1	1	1	1
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	262	1	1	2	2	2	3	1	1	1	1	3	1	1
180	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reps	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	11	1	1	1	1	1	3	1	1	1	3	1	1	1
181	65	1	2	2	3	1	3	1	1	1	1	3	1	2
Reps	111	1			1	1	3	1	1	1	1	1	1	1
4	169	1	1	1	1	1	2	1	1	1	1	2	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.208333	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	219	1	1	1	1	1	1	1	1	1	1	1	1	1
182	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Reps	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	146	1	1	2	3	2	1	3	1	1	1	1	1	1
183	423	1	1	3	3	3	2	3	1	1	1	2	1	1
Reps	451	1	1	3	1	3	1	3	1	1	1	1	1	1
5	529	1	1	2	3	3	1	2	1	1	1	1	1	1
Score	530	1	1	2	2	4	2	2	1	1	1	1	1	1
2.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	14	1	1	1	1	1	1	1	1	1	1	1	1	1
184	68	1	1	1	2	1	1	2	1	1	1	2	1	1
Reps	295	1	1	1	1	1	1	1	1	1	1	1	1	1
5	300	1	1	1	2	1	1	1	1	1	1	3	1	3
Score	334	1	1	1	1	1	1	1	1	1	1	1	1	1
1.15	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	122	1	1	1	3	3	1	3	1	1	1	3	1	3
185	160	1	1	1	3	3	3	3	1	1	1	3	1	3
Reps	238	1	1	2	3	3	1	3	1	1	1	2	1	2
4	321	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.583333	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	206	1	1	2	3	2	1	3	1	1	1	2	1	3
186	304	1	1	1	3	2	1	3	1	1	1	2	1	3
Reps	307	1	3	3	3	2	1	3	1	1	1	2	1	3
5	371	1	1	1	3	2	1	2	1	1	1	2	1	2
Score	494	1	1	1	2	2	1	3	1	1	1	2	1	3
2.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	198	1	1	1	1	1	1	1	1	1	1	3	1	1
187	208	1	1	1	1	1	1	1	1	1	1	3	1	1
Reps	375	1	1	1	1	1	1	1	1	1	1	1	1	1
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	-	-	-	-	-	-	-	-	-

APPENDIX

	#	D	DV	DLPJ	LC	LD	SS	CC	CH	SA	BR	DM	PM	DD
GT	233	1	1	1	3	1	1	2	1	1	1	1	1	1
188	343	1	1	1	3	3	2	2	1	1	1	3	1	1
Reps	392	1	1	2	3	3	2	2	1	1	1	3	1	1
4	418	1	1	3	3	1	3	2	1	1	1	1	1	1
Score	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2.1875	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GT	159	1	1	1	2	1	1	1	1	1	1	3	1	1
189	188	1	1	1	2	1	1	1	1	1	1	3	1	1
Reps	291	1	1	1	3	3	1	1	1	1	1	3	1	1
6	347	1	1	1	2	1	1	1	1	1	1	1	1	1
Score	348	1	1	1	3	1	1	2	1	1	2	2	1	2
1.458333	421	1	1	2	1	1	3	1	1	1	2	1	1	1